Essays in Immigration Economics

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Dedication

To my parents...

Abstract

The three main chapters of this dissertation focus on topics in Immigration Economics. In Chapter 2, we present a review of some of the most influential contributions in the literature grouped under two independent, yet connected lines of work that most closely relate to the rest of this dissertation: (1) Self-selection of immigrants, and (2) The impact that movements of labor across countries have on receiving economies. The chapter is not meant to be an exhaustive treatment of the scholarly contributions in the field, but rather provide a high-level summary of the most important findings and the different methodological approaches used to evaluate questions in Immigration Economics.

In Chapter 3, we quantify the long-run impact that the introduction of a new immigration policy, pursuant to which only highly-educated individuals would be able to immigrate to a richer economy, would have. We investigate how such a policy would affect the incentives to invest in physical and human capital and how it would impact the total immigrant population of the receiving economy. We have explored these questions through the lens of a two-country, life-cycle, general equilibrium model, which features investment in human and physical capital, as well as endogenous migration decisions. Consistent with a lot of the literature on Immigration Economics, in our model most of the labor movements stems from the higher wages in the receiving country. A novel feature of the framework presented in this dissertation, is that the change of policy leads to changes in incentives and endogenous adjustments within the model. We have calibrated the model so that it is consistent with data on labor movements between the United States and the rest of the world, and have run a number of policy experiments to quantify the impact of limiting these movements to individuals with certain levels of human capital relative to workers in the receiving economy. Results indicate that in the long-run, both economies experience relatively

small changes in wage rates and output per capita, while the size of the immigrant population experiences a more significant decrease.

In Chapter 4 we present a number of extensions to the model in Chapter 3. We introduce return migration and partially portable human capital when living abroad. We also build out a more realistic structure for the labor productivity shocks and allow for the possibility that agents' productivities may depend on their country of residence. The results obtained from the extended model are qualitatively similar to those in Chapter 3.

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Chapter 1

Introduction

Developed countries differ significantly when it comes to the extent to which they use some measure of human capital when determining the number and selection of individuals that will be allowed to immigrate. Some countries such as Canada, Australia, and New Zealand admit a large percentage of their immigrants based on education level and work experience. Other developed countries such as the United States, France, and Japan focus more on considerations such as family connections and geography, and allocate a relatively small percentage of their total immigration quotas based on factors such as education level or work experience. A large body of existing research in Immigration Economics shows that reducing labor movement barriers and increasing immigration quotas leads to significant welfare gains for both, sending and receiving countries.[1] Changes in how these quotas are allocated, however, have received far less attention. This dissertation attempts to fill this gap by quantifying the long-run impact of introducing an immigration policy that only admits highly educated individuals. It also measures how such a policy affects incentives to invest in human capital in each country.

The approach we have taken to examine these questions relies on a two-country, life-cycle, general equilibrium model in which agents can invest in human and physical capital and can decide whether to migrate or not. Higher wages in the receiving

[1] See Kennan (2013), Klein and Ventura (2009) and Lee (2016)

country create an incentive for agents born in the sending country to migrate. There are two features in the model that will not allow for a mass exodus from one country to the other. First, agents need to pay immigration costs in order to relocate. In our model agents are introduced to the economy without any physical assets. As such, the costs associated with relocation make it impossible for them to migrate during the first few years of their lives. The other factor, one that is explored in Chapter 4 where we present a number of extensions to the model, allows for agents to only be able to use part of the human capital they have accumulated in their native country when living abroad. This downgrade in human capital is attributable to factors such as difficulties with the language or formal recognition rules to foreign education credentials, which have been extensively documented in the Immigration Economics literature.

A novel feature of the model presented in this dissertation is that migration and (as in Chapter 4) return migration arise naturally every period as the optimal decisions of utility-maximizing agents. We calibrate the model so that it is consistent with the most recent data on labor movements between the United States and Rest-of-the-World economies. We then use the calibrated model to quantify the impact of limiting such movements to individuals with a level of human capital that exceeds certain thresholds.

Our results suggest that the long-run effects of limiting these movements are small. Both countries experience modest changes to their wage rates and increases in the output per capita. Further, the new policy creates additional incentives for agents born in the sending country to accumulate human capital. As such, the average levels of human capital in the sending country will also experience an increase. Because of the restrictive nature of this counterfactual policy, the size of the immigrant population in the receiving country experiences a significant decrease in the long-run. While the extensions presented in Chapter 4 allow us to more accurately capture a number of features documented in the Immigration Economics literature, omitting such features and presenting a simpler model such as the one we present in Chapter 3 does not qualitatively change our results on the long-run impact of the policy examined.

The rest of the dissertation is organized as follows. In Chapter 2 we provide a high-level summary of some of the most relevant, influential papers in Immigration Economics upon which this dissertation is built. In Chapter 3, we introduce a simple, heterogeneous agent, two-country model. In Chapter 4 we present an extension of the model. We introduce return migration, partially portable human capital when living abroad, and provide a more realistic structure to labor productivity shocks and allow for the possibility their underlying distribution may depend on an agent's country of residence. Chapter 5 summarizes our conclusions, discusses the limitations of our analysis, and outlines avenues for future research.

Chapter 2

Literature Review

Immigration Economics is a fast-growing and exciting area of research with significant policy implications. The purpose of this chapter is not to provide an exhaustive treatment of the scholarly contribution in the field, but rather to give a high-level summary of the most important findings, walking the reader through some of the questions asked related to Immigration Economics and the approach followed in answering them. The summary is grouped under two independent, yet connected lines of work that most closely relate to the rest of this dissertation: (1) Self-selection of immigrants, and (2) The impact that movements of labor across countries have on receiving economies. The subsections below provide a high-level analysis of each.

2.1 Self-Selection of Immigrants

In order to understand how changes in the skill distribution of immigrants admitted in a country impact the economy of that country, one needs to understand the reasons why people choose to migrate. A lot of previous research has focused on the reasons behind moving from one geographic area to another. Sjaastad (1962) identifies public and private costs and benefits associated with migration and presents a framework that can be used to to estimate them. For Sjaastad, immigration is a form of investment that increases productivity. As such, just like any other investment, has costs and returns, the latter particularly important when testing the effectiveness of migration in reducing earnings differentials over geographies. He concludes that age is an important variable that influences migration decisions and must be considered when interpreting income differentials among occupations. The relationship between private and social costs and benefits of migration will depend on the market structure, resource mobility, and government policies. Kennan and Walker (2011) explore the role of expected income as the main driver of migration. They develop a discrete-choice econometric model where heterogeneous agents maximize expected lifetime income by choosing, in every period, whether to stay or migrate to one of the several locations available to them. Locations are distinguished by known differences in wage distribution. Agents receive a wage premium if they live in their home countries, while if they choose to relocate, they draw a wage from a location only after moving there and paying moving costs. The authors use National Longitudinal Survey of Youth panel data to show that expected income plays a significant role in determining migration decisions. Their estimates indicate that the relationship is in good part driven by the negative effects that wage draws in the current location have on the probability of relocating for both high school and college graduates.

Questions around whether immigrants are selected from the upper end of the earnings distribution in their home countries and whether they are likely to do better than native workers in the destination countries have been important themes in the Immigration Economics literature. Borjas (1987) develops a two-country Roy-model,[1] where wages in the two countries follow log-normal distributions with country-specific mean and variance parameters. A worker will decide to relocate if the wage drawn in the foreign country exceeds the wage drawn in the home country by more than associated relocation costs. In Borjas (1987) immigrants are said to be positively selected if they earn more than the average worker in the home and destination countries, and negatively selected if they earn less. Borjas uses this framework to show that when wages in the two countries are sufficiently correlated immigrants will be positively selected if income dispersion is lower in the home country than in the destination

[1] See Roy (1951)

country, and negatively selected if income dispersion is higher in the home country than the destination country. Immigrant earning data from the 1970 and 1980 Census show that there are country-specific fixed effects in the earnings of foreign-born workers. Immigrants from Western Europe earn higher wages in the United States than immigrants from other countries, and their cohorts achieve an increase in earnings relative to the U.S. population. The empirical analysis also shows that immigrants that earn high wages in the U.S. generally come from high-income countries that have low levels of inequality and a politically competitive system. Chiquiar and Hanson (2005) develop a model similar to Borjas's and are able to show that the result that immigrants are negatively selected if income dispersion is higher in the home country than in the destination country hinges on the size of migration costs and their correlation with skill. They use 1990 and 2000 data from Mexico's Census of Population and Housing to document that relative to non-immigrants, Mexican immigrants are less likely to have nine years of education or less, more likely to have 10-15 years of education, and less likely to have more than 16 years of education. Chiquiar and Hanson are able to show that young adults with moderately high numbers of years of schooling are the most likely to immigrate to the U.S. Were these individuals to look for employment in Mexico, they would likely be placed in the middle and upper-middle portion of the wage distribution. While the higher dispersion of earnings in Mexico relative to the U.S. suggests that low-wage individuals in Mexico would have the most to gain by moving to the U.S., Chiquiar and Hanson argue that the reason why this is not what the data shows, is that moving costs are higher for this group than for high-wage individuals, who through their resources can navigate the immigration system better. Ibarraran and Lubotsky (2007) use 2000 Mexican and U.S. Census data to document how the educational attainment of Mexican immigrants in the United States compares to that of non-immigrants in Mexico. Their results, that low-skilled Mexicans are more likely to migrate to the United States than high-skilled Mexicans and that regions in Mexico where the returns to education are large are associated with more low-skilled immigrants than regions in Mexico where the returns to education are low, align with the predictions in Borjas (1987). Ibarraran and Lubotsky (2007) also document that the education levels of Mexican immigrants reported in the 2000 U.S. Census are higher than those reported in the 2000 Mexican Census. The discrepancy, Barraran and Lubotsky argue, can be explained by a combination of the particular sampling procedure of the Mexican Census, an under-count of young, largely illegal Mexican immigrants in the U.S. Census, and an over-reporting of education in the U.S. Census perhaps due to a misunderstanding of the grade and degree structure in the U.S. Their results suggest that Mexican immigrants are less educated than nonimmigrants. Moraga (2011) follows a similar two-country Roy-model framework to examine the selection of Mexican immigrants in the United States. Using data from ENET, a household survey used to calculate Mexico's official employment statistics, Moraga shows that during 2000-2004, Mexican immigrants earned lower wages and received on average fewer years of schooling than Mexican non-immigrants. McKenzie and Rapoport (2010) extend the two-country Roy-model of self-selection to account for the role that immigrant networks play in shaping the self-selection patterns of new immigrants. Their theoretical framework assumes that time-equivalent migration costs are decreasing in schooling as people with more education can more easily navigate the immigration process, and decreasing in the size of community migration networks, as a more robust community migration network makes it easier for new immigrants to navigate the immigration system and find a job in the destination country. McKenzie and Rapoport (2010) are able to show that larger migrant networks increase the incentive to immigrate at all education levels doing so more at the lower levels, and reduce the average level of schooling among immigrants. They use data from the 1997 household schooling data from the Encuesta Nacional de la Dinamica Demografica, a national survey conducted by Mexico's national statistical agency to show that education levels are negatively correlated with migration patterns and positively correlated with high community migration prevalence suggesting the selection is negative and strong when migrant networks are large, and positive and weak when migrant networks are small. Their results are found to be robust to instrumenting for immigrant networks, accounting for the under-counting of immigrants who move with their entire household to the United states and to using different definitions for migrants. Grogger and Hanson (2011) develop a multi-country, discrete-choice model where workers in the source country earn wages based on their education level returns to education in the destination country. Migration costs have a fixed component and a component that varies by education level. Both components depend on the source-destination country combination as to capture effects such as distance or language differences. The utility from moving to a destination country is the linear difference between wages and cost and an unobserved additive idiosyncratic term. Grogger and Hanson (2011) use this model to derive conditions for positive and negative selection of immigrants. If the source-destination wage difference is greater for high-educated workers, their model suggests that immigrants in the destination country will be positively selected. If the source-destination wage difference is greater for low-educated workers, the model suggests immigrants will be negatively selected. This result is then extended to show that if return to education is higher in destination country A than in destination country B, then destination country A will receive a mix of immigrants that is on average more educated than the mix of immigrants that destination country B will receive. In their empirical analysis, Grogger and Hanson (2011) use immigrant stock data segmented by education level from a number of OECD countries to confirm that the results align with the predictions of the theoretical model. Kaestner and Malamud (2014) use a two-country Roy-model where workers in Mexico decide whether to relocate to the U.S. on the basis of potential wage differences net of migration costs, which in their model are a linear function of their level of education. They show that the education level of Mexican immigrants in the U.S. can be expressed as the sum of two components: the average level of schooling and a "selection" effect, which depends on the difference between the premium that the return to schooling commands in the U.S. relative to Mexico and the relationship between migration costs and schooling. Without any such relationship (i.e. if mobility costs do not depend on the level of education) immigrants will be positively selected if the premium is positive and negatively selected otherwise. However, positive selection of immigrants may result in situations where the premium of education in the U.S. relative to Mexico is negative, provided that migration costs are inversely related to the level of education. In the presence of unobserved skills Kaestner and Malamud (2014) show that a positive correlation between migration costs and unobserved skill increases the likelihood of negative selection, while a negative correlation increases the likelihood of positive selection. Data from the Mexican Family Life Survey suggests that Mexican immigrants in the U.S. are intermediately selected in terms of educational attainment and earnings. Evidence for selection based on unobserved skills is much weaker.

2.2 Impact on Domestic Labor Markets

Another related line of work in Immigration Economics studies the impact of immigration on domestic labor markets. Many early studies suggest that more immigration reduces native wages, but the effect is rather small.[2] In particular, Card (1990) examines the effects of the 1980 Mariel boat-lift on the wages and unemployment rates of low-skilled workers of different ethnicities. Following Castro's April 20, 1980 declaration that the port of Mariel would be opened to anyone wishing to leave Cuba, about 125,000 Cubans arrived in Miami in privately chartered boats. About fifty percent of these arrivals settled permanently in Miami, resulting in a 7 percent increase in the labor force. Because the new immigrants were relatively low-skill, Card looks at data from the Current Population Survey to assess the impact on wages and unemployment rates in low-skill occupations and industries in Miami. The data suggests that there was virtually no effect on wages or unemployment rates among low-skill non-Cuban workers. While there is some evidence that the influx may have affected wages and unemployment rates of other Cuban immigrants, the changes were small, perhaps due to Miami's economy's ability to accommodate the new supply. Borjas et al. (1996) use 1980 and 1990 decennial Census data to estimate the effects of increased labor supply

[2]See Grossman (1982), Greenwood and McDowell (1986), Borjas (1987), LaLonde and Topel (1991)

due to immigrants on native wages. They regress the change in "geographic area - education" group wages on the change in the "geographic area - education" group ratio of immigrants to natives and a number of other regressors. Results suggest that as the geographic area under consideration widens, regression coefficients on the ratio of immigrants to natives switch from positive to negative suggesting a more depressant effect of immigrants on native wages. One possible explanation for the authors could be that the relocation of native workers as a response to immigration-induced changes in wages overstates the immigration-induced increase in labor supply. For Borjas et al., possible explanations for this include native worker re-locations or capital inflows that offset the effects of immigration on native outcomes in smaller geographic areas. Card and DiNardo (2000) however reject the possibility native worker re-locations have offset the effects of immigration on native outcomes. Using data from the 1970, 1980, and 1990 decennial Censuses, they regress the relative growth rate of natives in a given skill group on the relative growth rate of immigrants in that same skill group and a set of exogenous covariates. Their estimates show that there is no evidence that native out-migration rises in response to immigrant inflows. Using the 1970 fraction of Mexican immigrants in each skill group as an instrumental variable for the relative growth in the immigrant population in that skill group, Card and DiNardo (2000) find that the sign of the coefficient is, perhaps surprisingly still positive (i.e. that increases in immigrant population in specific skill groups have actually led to increases in the population of native-born individuals of that skill group). Their study suggests that systematic out-migration of natives likely does not provide an explanation for the small, measured effects that immigration has had on labor-market outcomes of native workers.[3] Borjas's approach in Borjas (2003) estimates the impact of immigration on labor market outcomes of native workers by exploiting the variation in the supply of immigrant workers across different education - experience groups. Using 1960 - 1990 decennial Census data and 2001 Current Population Survey data, Borjas regresses a number of labor market outcome for native workers (log annual earnings, log weekly earnings, fraction of time worked) on the foreign-born share of the labor force in a

[3]See Borjas et al. (1996)

particular skill group and vectors of fixed effects indicating the group's educational attainment, work experience, cohort, and all possible interactions. Data suggests that for different specifications of the model, the coefficient of the foreign-born share of the labor force is negative, indicating that immigration reduces the wage and supply of competing native workers. Focusing their analysis on a national scale, Aydemir and Borjas (2007) measure the labor market impact of immigration in Canada, Mexico, and the United States. Using data from the national census of each country, Aydemir and Borjas (2007) use a regression model similar to the one in Borjas (2003). Their findings suggest that there is a sizable and statistically significant inverse relationship between changes in immigration levels and wages in all three countries. More specifically, they find that a 10 percent immigrant-induced increase in the number of workers in a particular skill group is associated with a 3 - 4 percent decrease in wages. Because the selection of immigrants in the U.S. and Canada is different, Aydemir and Borjas (2007) show the decrease in wages lowered wage inequality in Canada and increased it in the U.S. In Mexico, since emigration rates are higher among workers in the middle of the skill distribution, labor outflows increased the relative wage of workers in the middle of the skill distribution, but lowered that for workers at the bottom of the distribution. Steinhardt (2011), develops a model similar to the one in Borjas (2003) and uses 1975-2001 data from the Institute of Employment Research ("IAB") to estimate the impact of increases in the number of workers of a particular skill group on wages of natives in Germany. Results from the baseline model suggest that a 10 percent immigration-induced increase in the number of workers of a skill group is associated with a 0.48 percent reduction of the wages of native workers. To account for the possibility that in Germany natives and immigrants of the same skill group do not compete for the same jobs, Steinhardt extends the analysis to the occupational level. Within occupational groups, a 10 percent immigration-induced increase in the workforce is associated with a 3.94 percent reduction in native wages. Steinhardt argues that, at least for the German market, using formal education as the exclusive classification criterion may lead to an underestimation of the impact of immigration on native wages. Borjas (2015) does a reappraisal of the labor market impact of the Mariel boatlift. ACS data is used to document the number of Cuban immigrants that arrived to the U.S. each year from 1955 to 2010 and, specifically for the Mariel boatlift immigrants, to document the magnitude of the influx as well as the skill distribution of the new arrivals. Data suggests that the Mariel boatlift increased the size of the labor force by 55,700 individuals, of which about 60 percent were high school dropouts. Across education groups, the boatlift increased the number of the most educated workers by 3 - 5 percent, and the number of high school dropouts by 18.4 percent. Focusing on the changes of wages of male high school dropouts in Miami and in other metropolitan areas, Borjas documents that the Mariel experience ranked in the first percentile of the distribution of observed wage changes across all metropolitan areas. Borjas develops a model regressing log wages of male high school dropouts on city and cohort fixed effects as well as on a Miami-post Mariel cross effect dummy variable. Results suggest that the wage effect immediately after the Mariel boatlift is negative, indicating a decline in the wages of low-educated workers in Miami. The wage impact was stronger between 1983 and 1986 than 1981 and 1983. On average the first six years following the boatlift led to a 20-30 percent decline in the wages of male high school dropouts. The wage effect weakened after 1986 and essentially disappeared by 1990. Peri and Sparber (2009) develop a model of task specialization and use it to illustrate the effects of immigration on wages. In their model, high-skill and low-skilled workers both work for competitive firms to produce an output that combines high and low-skill components via a CES function. Domestic and foreign low-skill workers choose the fraction of their labor endowment that they will spend performing manual tasks and communication tasks to maximize wage income. A natural assumption that Peri and Sparber (2009) make is that domestic workers have a competitive advantage in communication tasks while foreign workers have a competitive advantage in manual tasks. Using this model, the authors analyze the impact that an increase in the share of immigrants will have in equilibrium. They are able to show that an increase in the share of immigrants will lead to a decrease in the aggregate level of communication tasks thus increasing their relative compensation. Because of their comparative advantage in providing communication tasks, in equilibrium, native workers respond by providing more such tasks increasing therefore the relative supply of these tasks among natives. U.S. Department of Labor O*-NET data on task composition of occupations in the U.S. between 1960 and 2000 suggests that less educated immigrants supplied more manual tasks relative to communication tasks than natives. Native workers switched to more communication intensive occupations in states where immigration inflows were large. At the same time the immigration-induced change in manual tasks is associated with an increase in wages for communication-intensive occupations. Peri and Sparber (2009) conclude that if there is a decrease in wages among native workers caused by immigrant inflows, the effect is much smaller because of task specialization due to different comparative advantages among immigrants and native workers. Ottaviano et al. (2013) analyze the impacts that offshoring and immigration have had on employment outcomes of native workers within the U.S. manufacturing sector from 2000 to 2007. They use BEA data on the number of workers working abroad in foreign affiliates of U.S. companies and ACS data on native and immigrant workers to document a lack of correlation between the share of native and immigrant workers, a strong negative correlation between the shares of offshore and native workers and negative, but weaker correlation between the shares of offshore and immigrant workers. They are also able to document a positive correlation between growth rates of employment of natives and immigrants, while the correlation between the growth rates of the employment of natives and offshore workers is much weaker. With respect to skill composition, they document that the share of hours worked by immigrants is negatively correlated with the level of cognitive and communication skills and positively correlated with the level of manual skills required in manufacturing occupations. In a series of 2SLS regressions, the authors are able to show that immigrants and natives compete more with offshore workers than with one another. They are also able to show that a decrease in offshoring costs pushes native workers into more complex tasks but does not have a significant impact on the tasks that immigrants perform. Burstein et al. (2020) develop a theoretical model that identifies different labor market adjustment patterns within tradable and nontradable occupations. Individuals with occupations that attract large numbers of immigrants experience different consequences for their real incomes depending on whether they work in tradable or non tradable activities. More specifically, because of the adjustments occurring through changes in occupational prices, increases in the relative share of immigrant workers lead to changes in the wages native workers that are larger among those in less-tradable occupations than those in more tradable ones. Ottaviano and Peri (2012) use a general equilibrium model that relies on allocating immigrants to particular skill-groups and examine the effect of immigration on wages of U.S.-born workers during the period 1990-2004. They find that this increase in immigration has had a positive effect on wages of workers with at least a high school degree and a small and negative effect on wages of workers with no high school degree. Finally, Dustmann et al. (2012) use a structural approach that doesn't rely on pre-allocating immigrants to any skill-group and find that immigration has a negative impact on wages in the lowest quintile but leads to small increases in all other wages.

Benhabib and Jovanovic (2012) use a theoretical model to characterize different optimal migration policies. They find that under an egalitarian welfare function, the optimal policy is one that moves unskilled immigrants into rich countries, whereas under a welfare function that only focuses on rich countries, the optimal policy prescribes a brain-drain from poorer countries. A lot of existing research examines the economic effects of immigration through the lens of a general equilibrium model with overlapping generations. For example, Ben-Gad (2004) uses such a model to show that the shifts in wages and interest rates that result from changes in immigration will be small. Other papers such as Kennan (2013) and Klein and Ventura (2007) examine the effects of eliminating barriers to labor mobility. Kennan (2013) uses a static model of migration costs and location specific labor-augmenting productivity. He estimates that there are large gains associated with the complete elimination of labor movement restrictions. On the other hand, Klein and Ventura (2007) use a two-country growth model to examine the long-run efficient allocation of labor and capital. They characterize the implications of this efficient allocation on labor movements and find large gains in output associated with this efficient allocation. Klein and Ventura

(2009) propose a two-country life-cycle model with endogenous migration decisions and capital accumulation to examine the effects of reducing barriers to labor mobility. They show that due to cross-country differences in productivity and land, there are large welfare gains associated with the removal of barriers. Lee (2016) on the other hand uses a two-country life-cycle model with endogeneous migration decisions and human capital accumulation to examine the effects of doubling immigrant quotas. He finds modest increases in output per capita and welfare in the U.S. This increase in welfare is mostly due to the increase in interest rates. This dissertation expands on Lee (2016)'s framework by introducing cross-country differences in immigrant labor productivity and downgrades in human capital when living abroad. In addition, while Lee (2016)'s policy experiment is in line with much of the existing literature that examines the effects of reducing restrictions to labor movements, in this dissertation we have explored the effects of an immigration policy that changes the nature of such restrictions in favor of agents with high levels of human capital. Several other important departures in methodology are highlighted in different sections of the following two chapters.

Chapter 3

The Dynamic Effects of Merit-Based Immigration: A Two-Country Approach

This chapter introduces a two-country model where migration patterns arise endogenously in a heterogeneous agent economy. We begin by describing the environment. We then summarize the problems that agents and firms face in every period using dynamic programming, recursive formulations. Next we define a concept of equilibrium for the economy, and numerically characterize the baseline model equilibrium relying on a number of reasonable assumptions around the environment and functional form representations. We then proceed by asking the question: "Should there be a change in immigration policy that favors highly-educated individuals and restricts the relocation of everyone else, what does its long-run impact look like?" To quantify this impact, we run a few counterfactual policy experiments where migration is only limited to agents with certain levels of human capital. Comparisons between the characteristics of the stationary equilibrium of our baseline model to the characteristics of the stationary equilibrium in our counterfactual scenarios are presented in the last section of this chapter.

3.1 Environment

We consider a discrete-time economy consisting of two countries, denoted by R and P. Every period, an equal measure of agents is introduced in both countries. Agents in both countries make decisions in the economy for a finite number of periods, that we represent by T and then retire. We assume for simplicity that neither country R nor country P experiences demographic changes so that the measure of agents introduced in each country is constant over time. An agent's number of periods spent in the economy will be referred to as the agent's "age". Agents in each country are heterogeneous in that when they are introduced to the economy they have different levels of human capital endowment. Agents born in $i \in \{R, P\}$ are introduced to the economy with a human capital endowment h_o^i drawn from a country-specific probability distribution and no physical capital.

In each period, agents consume, accumulate physical and human capital, and supply labor inelastically. An agent of age τ has preferences over the consumption good characterized by a continuous, increasing, strictly concave utility function $u(c_\tau)$ and discounts future consumption at a rate $\beta \in (0,1)$. Physical capital is perfectly mobile so that agents in each country are able to trade ownership claims to physical capital located in any of the two countries. As such, physical capital earns the same rate of return in the two countries. For each unit of capital purchased at time t agents will receive $1 + r_{t+1}$ units at time $t+1$. Agents can also invest in human capital. Human capital is directly tradeable for consumption and its level evolves according to $h_{\tau+1} = (1-\delta_h)h_\tau + i_\tau$, where h_τ is the level of human capital of an agent of age τ, i_τ is the investment in human capital, and $\delta_h \in (0,1)$ is the depreciation rate of human capital.

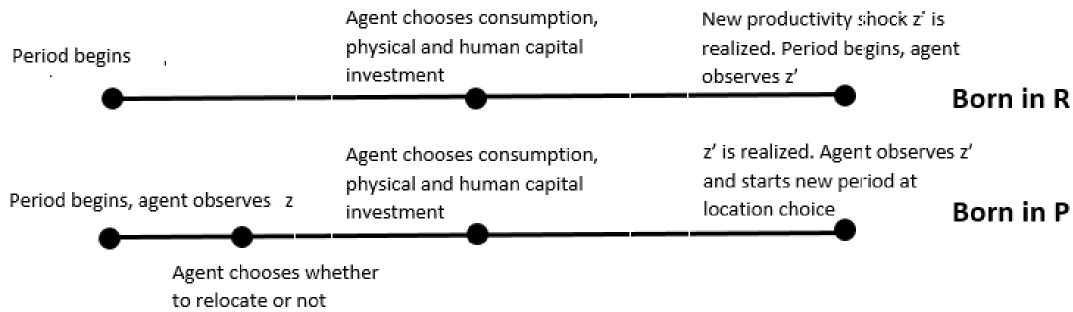
In addition to making consumption, human capital, and physical capital decisions in every period, agents born in P can also decide whether or not to migrate to R. Agents born in R on the other hand are unable to migrate to P. Agents born in P who choose to emigrate to R need to pay a fixed cost $\phi > 0$ upon arriving in their new country. For simplicity, it is assumed that ϕ does not depend on the agent's age or human capital. Agents of age $\tau \in \{0, 1, 2, \ldots, T\}$ that are born in R and have human capital h_τ supply a labor amount given by $l_\tau^R = h_\tau^\alpha$. Those that are born in P supply a labor amount given by $l_\tau^P = z h_\tau^\alpha$. The constant $\alpha < 1$ is the same across all agents regardless of age or country of birth, while z is a random productivity shock experienced only by agents born in P.

Finally, in each country there is a competitive firm that transforms capital and labor into output according to a the production function given by $Y_t^i = A^i G(K_t^i, L_t^i)$ where $i \in \{R, P\}$ represents the country and $t \in \mathbb{N}$ represents time. A^i is the exogenously given total factor productivity ("TFP") while K_t^i and L_t^i are, respectively, the aggregate physical capital and labor employed in production.[1]

3.2 Timing

The diagram below illustrates the model's timing assumptions with respect to the productivity shock within each period. As discussed in the section above, we have assumed that agents born in R do not experience any productivity shocks. Agents born in P observe the current-period productivity shock at the beginning of the period. Then they make their next period's consumption and investment decisions. In addition, agents born in P decide, at the beginning of every period, whether or not to relocate. If they decide to relocate, they have to pay the relocation cost ϕ at the end of the period and begin the next period in their new location. If they decide to remain, they don't have to pay any relocation costs, and begin their next period in the same country.

[1]Note that the subscript t represents the time since the economy began and not the age of any living agent. In this chapter, the latter is represented by a τ subscript



3.3 Agents' problems

In this section we provide the recursive formulations in connection with the problems faced by agents born in R and P. Agents born in R can be characterized by age, human capital, and assets. Since they cannot relocate to P and experience no productivity shocks, letting $V_\tau^R(h,a)$ represent the lifetime expected utility and w_R the wage rate paid by the firm in R, the problem they face can be written recursively as:

$$\begin{aligned} V_\tau^R(h,a) = \max_{c,h',a'} \quad & \left\{ u(c) + \beta V_{\tau+1}^R(h',a') \right\} \\ \text{s.t.} \quad & c + i + a' = a(1+r) + h^\alpha w_R \\ & i = h' - (1-\delta_h)h \\ & a \geq 0, \quad i \geq 0 \end{aligned} \tag{3.1}$$

Agents born in R receive income from assets purchased in the previous period and from working for the firm. This income is used to purchase consumption, new assets, and additional human capital. We have assumed for simplicity that agents cannot borrow physical assets. Alternative specifications include introducing a borrowing limit on assets, representing the agents' ability to borrow in financial markets. The other constraint, $i \geq 0$ represents the natural assumption around human capital as the type of capital that can be traded back in exchange for consumption goods only by converting into labor.

Agents of age $\tau = T$ face the terminal value function given by:

$$V^R_{T+1}(h, a) = 0, \quad \text{for all} \quad (h, a) \in \mathbb{R}^2_+.$$

This terminal value function weakens the incentives to invest in human and physical capital as agents get older and ensures that in their last period of life they will consume all their income. Alternative specifications where agents face a terminal value that is linear in physical capital add computational complexity while providing no significant added insight or materially changing the results presented in this chapter. As such, we use a zero terminal value specification like the one presented above.

Agents born in P are characterized by age, human capital stock, level of assets, productivity, and current residence. Agents starting the period in their country of birth P solve the following problem:

$$\begin{aligned}
V^{PP}_\tau(h, a, z) = \max_{c,h',a',m_R} \quad & \Big\{ u(c) + \beta \Big[m_R E\big[V^{PR}_{\tau+1}(h', a' - \phi, z')\big] + \\
& (1 - m_R) E\big[V^{PP}_{\tau+1}(h', a', z')\big]\Big]\Big\} \\
\text{s.t.} \quad & c + i + a' = a(1 + r) + w_P z h^\alpha \\
& i = h' - (1 - \delta_h) h \\
& a' - m_R \phi \geq 0, \;\; i \geq 0 \\
& m_R \in \{0, 1\}
\end{aligned} \tag{3.2}$$

Here $V^{PP}_\tau(h, a, z)$ represents the expected lifetime utility and m_R represents the decision to migrate to R. Since the agent pays the fixed migration costs upon arriving in R, if the agent migrates to R her next period's expected lifetime utility is given by $V^{PR}_{\tau+1}(h', a' - \phi, z')$. The value function $V^{PR}_\tau(h, a, z)$ represents the problem solved by the agent born in P who lives in R. Its general form is given given recursively by:

$$\begin{aligned} V_\tau^{PR}(h,a,z) = \max_{c,h',a',m_R} \quad & \left\{ u(c) + \beta E[V_{\tau+1}^{PR}(h',a',z')] \right\} \\ \text{s.t.} \quad & c + i + a' = a(1+r) + w_R z h^\alpha \\ & i = h' - (1-\delta_h)h \\ & a' \geq 0, \quad i \geq 0 \end{aligned} \tag{3.3}$$

As shown in the problem above, agents born in P that migrate to R remain there for the rest of their lives. In Chapter 4 we relax this assumption and allow for return migration for agents born in P. Finally, agents born in P who live at home or abroad face terminal value functions given by:

$$V_{T+1}^{PP}(h,a,z) = V_{T+1}^{PR}(h,a,z) = 0, \quad \text{for all} \quad (h,a,z) \in \mathbb{R}_+^2 \times Z$$

3.4 Firms' problem

Firms are competitive and maximize profits in every period. The problem that the firm in country $i \in \{R,P\}$ solves is given by:

$$\max_{K^i,L^i} \left\{ A^i G(K^i,L^i) - rK^i - w_i L^i - \delta_k K^i \right\} \tag{3.4}$$

where δ_k is the depreciation rate of physical capital.

3.5 Stationary Equilibrium

Let $S_R = \mathbb{R}_+^2$ be the state space for the agent born in R and $S_P = \mathbb{R}_+^2 \times Z$ be the state space for the agent born in P. A stationary equilibrium consists of:

1. Interest rate r and wages w_R, w_P;

2. Value functions for all types of agents at every age

$V_\tau^{PP} : S_P \to \mathbb{R}_+$, $V_\tau^{PR} : S_P \to \mathbb{R}_+$, $V_\tau^{R} : S_R \to \mathbb{R}_+$;

3. Policy functions for all types of agents at every age

   $c_\tau^{PP} : S_P \to \mathbb{R}_+$, $g_{a,\tau}^{PP} : S_P \to \mathbb{R}_+$, $g_{h,\tau}^{PP} : S_P \to \mathbb{R}_+$, $m_{R,\tau} : S_P \to \{0,1\}$
   $c_\tau^{PR} : S_P \to \mathbb{R}_+$, $g_{a,\tau}^{PR} : S_P \to \mathbb{R}_+$, $g_{h,\tau}^{PR} : S_P \to \mathbb{R}_+$
   $c_\tau^{R} : S_R \to \mathbb{R}_+$, $g_{a,\tau}^{R} : S_R \to \mathbb{R}_+$, $g_{h,\tau}^{R} : S_R \to \mathbb{R}_+$; and

4. Distributions of agents

   $\lambda_\tau^R(h,a)$, $\lambda_\tau^{PP}(h,a,z)$, $\lambda_\tau^{PR}(h,a,z)$

so that:

1. Given r and w_R, agent born in R chooses value functions V_τ^R and policies $c_\tau^R, g_{a,\tau}^R, g_{h,\tau}^R$ to solve the problem given in (3.1);

2. Given r and w_R, w_P, agent born in P who lives at home chooses value functions V_τ^{PP} and policies $c_\tau^{PP}, g_{a,\tau}^{PP}, g_{h,\tau}^{PP}, m_{R,\tau}$ to solve the problem given in (3.2);

3. Given r and w_R, w_P, agent born in P who lives abroad chooses value functions V_τ^{PR} and policies $c_\tau^{PR}, g_{a,\tau}^{PR}, g_{h,\tau}^{PR}$ to solve the problem given in (3.3);

4. Wages and interest rates are given by marginal products

$$\begin{aligned} w_R &= A_R G_2(K_R, L_R) \\ w_P &= A_P G_2(K_P, L_P) \\ r &= A_i G_1(K_i, L_i) - \delta_k \end{aligned} \tag{3.5}$$

5. Aggregation of capital and labor follows from the policy functions and the distributions $\lambda_\tau^R, \lambda_\tau^{PP}, \lambda_\tau^{PR}$;

$$
\begin{aligned}
K^R + K^P &= \sum_{\tau=1}^{T} \Big[\int_{S_R} g_{a,\tau}^{R}(h,a) d\lambda_\tau^R(h,a) + \int_{S_P} g_{a,\tau}^{PP}(h,a,z) d\lambda_\tau^{PP}(h,a,z) \\
&\qquad + \int_{S_P} g_{a,\tau}^{PR}(h,a,z) d\lambda_\tau^{PR}(h,a,z) \Big] \\
L^P &= \sum_{\tau=1}^{T} \Big[\int_{S_P} z h^\alpha d\lambda_\tau^{PP}(h,a,z) \Big] \\
L^R &= \sum_{\tau=1}^{T} \Big[\int_{S_P} z h^\alpha d\lambda_\tau^{PR}(h,a,z) + \int_{S_R} h^\alpha d\lambda_\tau^{R}(h,a) \Big]
\end{aligned}
\tag{3.6}
$$

6. If Q is the law of motion between states induced by policy functions and stochastic kernels, then the distribution λ satisfies: [2]

$$
Q \circ \lambda = \lambda. \tag{3.7}
$$

3.6 Calibration and Results

In this section we discuss the calibration exercise performed and summarize some of the of the characteristics of the stationary equilibrium defined in the section above. At a high level, we have calibrated agent and firm-specific characteristics using parameters that are standard in the literature. Parameters in connection with R and P are chosen based on U.S. and Rest-of-the-World ("RoW") data.[3] The subsections below describe the functional forms selected and the assumptions made for this numerical exercise in more detail.

[2] A formal definition of Q is presented in the appendices

[3] Since only ten countries: Mexico, Cuba, China, India, the Dominican Republic, Philippines, Vietnam, El Salvador, Haiti, and Jamaica account for the majority of the most recent new permanent residents by country of birth, with the effects of any other country on U.S. immigration rates virtually negligible, we limit our parametrization in connection with RoW to estimates derived using data from these ten countries

3.6.1 Environment

We have chosen the total number of periods that agents in each country live to be $T = 47$ to approximately capture the number of years individuals typically make decisions and work for before they retire.

3.6.2 Agents - Preferences

Since each period in the model is chosen to represent one year, a $\beta = 0.96$ discount factor is chosen to align with the standard intertemporal discounting that is used in much of the macroeconomic literature. Agent preferences are captured by the standard CRRA utility function $u(c) = (c^{1-\sigma})/(1-\sigma)$. Estimates for the coefficient of relative risk aversion aversion σ vary in the literature between 1 and 4 with a mean of 2, so we have used a value of $\sigma = 2$ for this exercise.

3.6.3 Agents - Human Capital

As discussed in Section 3.1 above, agents in R and P are heterogeneous with respect to their endowment of human capital when they are introduced to the economy. Our assumption, which is standard in the human capital literature, is that the distribution from which the initial level of human capital of an agent born in $i \in \{R, P\}$ is given by $\ln(h_o^i) \sim \mathcal{N}(\mu_i, \sigma_i^2)$. We follow the approach in Lee (2016), and calibrate the moments of human capital so that the youngest cohort's average human capital in R is 56.38 percent higher than in the youngest cohort's average human capital in P, while keeping the variances of the log-normal distribution the same across the two countries. The coefficient of labor with respect to human capital α is assumed to be 0.85, which is standard in the literature.

3.6.4 Agents - Productivity

As discussed in Section 3.1 above, agents born in P are subject to productivity shocks so that the labor they supply is given by $l_\tau^P = zh_\tau^\alpha$. To keep the assumptions simple and the exercise computationally tractable, we have assumed agents will either be fully productive so that $z = 1.00$, or 80 percent productive so that $z = 0.80$. We assume that z is independently and identically drawn from a Binomial distribution with a country-invariant productivity parameter $p = 0.50$. These assumptions around agents' labor productivity will be further extended into a more complex stochastic process in Chapter 4.

3.6.5 Firms - Production

Output in each country is produced according to a Cobb-Douglas production function $A^i(K^i)^{(1-\nu)}(L^i)^\nu$, where ν and $1 - \nu$ are the labor and capital shares respectively. Karabarbounis and Neiman (2013) document a significant decline in labor share globally since the early 1980s, roughly half of which can be explained by the lower relative price of investment goods. Their estimates of the most recent share of output attributable to labor is approximately 59 percent. As such, we have selected $\nu = 0.59$.

Using Penn World Table 2017 TFP data we have estimated that the population-weighted purchasing power parity ("PPP")-adjusted TFP of RoW countries is about 2.32 times lower than that of the United States. As such we have used the normalization $A_P = 1$ and have set A_R to be equal to 2.32.

3.6.6 Relocation Costs

The fixed costs ϕ that agents born in P incur when relocating to R have been calibrated to match the moments from U.S. immigration data. More specifically, given that the share of new arrivals to the U.S. that are 30 years or older has increased from 34 percent in 2000 to more than 48 percent in 2017 as shown in Figure D.1, the fixed cost ϕ is calibrated to target this share in the stationary equilibrium of the baseline model.[4] We have performed an alternative calibration where relocation costs ϕ are

[4] Public-use files of the 2000 census and the 2001 to 2017 American Community Surveys. Retrieved from https://cis.org/Report/Immigrants-Are-Coming-America-Older-Ages

chosen so that the model-generated measure of agents born in P who live in R as a fraction of the total measure of agents that live in R in the stationary equilibrium matches the share of the total foreign-born population in the U.S. Results form the alternative calibration are qualitatively similar.

3.6.7 Stationary Equilibrium results

Table A.1 summarizes the parameters we have chosen to calibrate the stationary equilibrium of our baseline model. In this section we provide a number of observations on the characteristics of the stationary equilibrium, while in Section 3.7 below we use the same parameters to quantify the long-run effects that a change in immigration policy would have on the macroeconomic aggregates in the two countries.

Figure D.2 shows the stationary equilibrium distribution of human capital among the youngest cohort for agents born in P and those born in R. As expected, the distribution of human capital among these agents will reflect their draw of h_o^R or h_o^P, which is one of the sources of agent heterogeneity in our model. Figure D.3 shows the distribution of P-born agents in R for each age group in the stationary equilibrium. Because migration requires liquidating some of the physical assets on the front end, and given that agents are introduced to the economy with no such assets, the model exhibits no immigration among agents of the youngest cohorts. Older cohorts account for a large fraction of total immigrants as these agents have been able to accumulate physical capital over time and as such, are able to afford to relocate. Figure D.4 further illustrates this, showing the immigration pattern of agents born in P. Most of the migration happens in the early twenties, with rates among older cohorts closer to zero. While the model does a decent job at matching the general pattern of new arrivals and the share of under 30 year old immigrants, it under-predicts new arrivals among the youngest and oldest cohorts. The reason why it under-predicts new arrivals among the youngest cohorts is because we have assumed, for simplicity, that all agents are born without any physical assets. As such, no agents are going to be able to immigrate in the first few periods, regardless of their human capital draw. Having a model where agents start out with both an initial human capital draw and an initial physical capital draw, would generate more immigration in the stationary equilibrium among younger cohorts. The reason why the model under-predicts new arrivals among older, working-age cohorts is that in our model most of the migration happens earlier in the lives of the agents. Having a model with immigration quotas or non-monetary restrictions associated with moving to a foreign country would generate a pattern that more closely aligns to data on new arrivals to the U.S. by age with respect to older working-age arrivals.

Figure D.5 shows the average human capital held by agents born in R and by those born in P living in R for each age group. Because agents born in R start out at a higher level of human capital due to their favorable draw, they continue to own more human capital than immigrants in R for a number of years until both groups eventually hit a satiation point after which both groups own the same level of human capital. An interesting feature of our stationary equilibrium is shown in Figure D.6. Because immigration among agents of younger cohorts is low, certain agents in the younger cohorts, who had a relatively large draw of initial human capital when they were introduced to the economy, are able to quickly use their labor income to purchase physical capital early in their lives, which will then allow them to relocate to R. As such, the average physical capital of this selected group exceeds that of agents born in R. Once in R these agents are able to receive the higher w_R wage level so their incentive to quickly accumulate physical capital is relatively lower as the relative importance of investing in human capital becomes larger. This is reflected in the lower level of physical assets compared to agents that live in R.

3.7 Policy Experiment

In this section we discuss the long-run effects of a change in the way RoW workers are admitted in. While some of the previous work (e.g. Klein and Ventura (2009), Kennan (2013), and Lee (2016)), uses two-country models to quantify the effects of reducing labor movement restrictions between countries, our policy experiment exercise focuses on the effects of a change in the nature of these restrictions. The exercise will assume that country R only allows the immigration of agents bringing a human capital level above a certain threshold ζ, determined in relation to the average human capital of native born workers, with them. All other agents are unable to relocate for that period, but may do so in later periods of their life. The range of ζ values we have chosen for this exercise is characterized by the equation below:

$$\zeta e^{-(\mu_R+\frac{\sigma_R^2}{2})} - 1 = \kappa$$

where μ_R and σ_R^2 are defined in Section 3.6.3 above and the range of values for κ is summarized in Table A.2. Intuitively, we are choosing a range of levels for ζ so that in the new counterfactual policy, only potential workers who have human capital levels at least a certain percentage kappa larger than the average human capital level of the 20-year old native worker are able to relocate.

The problem of the agent born in P who lives at home will now be

$$V_\tau^{PP}(h,a,z) = \begin{cases} \tilde{V}_\tau^{PP}(h,a,z) & \text{if} \quad h < \zeta \\ \hat{V}_\tau^{PP}(h,a,z) & \text{if} \quad h \geq \zeta \end{cases} \tag{3.8}$$

where $\hat{V}$ and $\tilde{V}$ are given by

$$\begin{aligned} \hat{V}_\tau^{PP}(h,a,z) = \max_{c,h',a',m_R} \quad & \Big\{u(c) + \beta\Big[m_R E\big[V_{\tau+1}^{PR}(h', a'-\phi, z')\big] + \\ & (1-m_R)E\big[V_{\tau+1}^{PP}(h',a',z')\big]\Big]\Big\} \\ \text{s.t.} \qquad & c + i + a' = a(1+r) + zh^\alpha w_P \\ & i = h' - (1-\delta_h)h \\ & a' \geq 0, \quad i \geq 0 \\ & m_R \in \{0,1\} \end{aligned} \tag{3.9}$$

and

$$\begin{aligned}
\tilde{V}_{\tau}^{PP}(h,a,z) = \max_{c,h',a',m_R} \quad & \left\{u(c) + \beta E\left[V_{\tau+1}^{PP}(h',a',z')\right]\right\} \\
\text{s.t.} \quad & c + i + a' = a(1+r) + h^{\alpha} w_P \\
& i = h' - (1-\delta_h)h \\
& a' \geq 0, \quad i \geq 0
\end{aligned} \tag{3.10}$$

3.8 Comparison of Stationary Equilibria

The key results from the comparison of the two stationary equilibria are summarized in Table A.3. Two striking features emerge. First, the impact of this policy on prices and macroeconomic aggregates is small. Our results for Specification (1) suggest that wages rates in both countries increase by 0.19 percent. The aggregate level of capital increases in P by 4.76 percent and decreases in R by 0.19 percent. The level of aggregate human capital in R and P is defined as:

$$\begin{aligned}
H^R &= \sum_{\tau=1}^{T}\left[\int_{S_P} h \cdot d\lambda_{\tau}^{PR}(h,a,z) + \int_{S_R} h \cdot d\lambda_{\tau}^{R}(h,a)\right] \\
H^P &= \sum_{\tau=1}^{T}\left[\int_{S_P} h \cdot d\lambda_{\tau}^{PP}(h,a,z)\right]
\end{aligned} \tag{3.11}$$

Our results for Specification (1) suggest that aggregate human capital in R decreases by 0.66 percent while in P increases by 4.68 percent, with changes in labor supplied directionally and quantitatively similar in each country. The long-run effects of this policy on output per capita are small. Output per capita in R increases by 0.89 percent while that in P increases by 1.81 percent. Results for Specification (2), where κ is set to 50 percent, are qualitatively similar, and summarized in Table A.3.

An important feature that emerges from comparing the two stationary equilibria is the decrease in the measure of agents born in P who live in R. If we denote this measure by M, then

$$M = \sum_{\tau=1}^{T} \Big[\int_{S_P} d\lambda_{\tau}^{PR}(h, a, z) \Big]$$

is reduced in the long-run by 5.50 percent. Therefore, the counterfactual policy that only allows agents with 20 percent more human capital than the average level of human capital among young natives to immigrate to R leads to modest changes in wage levels and output per capita in both countries and reduces the number of P born agents in R more significantly.

Figure D.8 shows that in the new stationary equilibrium the measure of agents born in P who live in R is reduced. For any age group, there are at least as many such agents in the stationary equilibrium of our baseline model as in the stationary equilibrium in our policy experiment. In addition, agents born in P who live in R in the stationary equilibrium of our baseline model have higher levels of human capital on average than agents born in P who live in R in the new stationary equilibrium. Figure D.7 shows the cumulative distribution functions of human capital in the old and new stationary equilibria. As the graph shows, one of the effects of the new policy is that it makes immigrants in R more positively selected in terms of human capital.

Finally, we note that the results presented above will qualitatively hold under Specification (2) where the policy is even more restrictive. Under Specification (2), modest changes in wage levels and output per capita in both countries are accompanied by a 10.73 percent decrease in the number of P born agents in R. Table A.3 summarizes the results.

Chapter 4

The Dynamic Effects of Merit-Based Immigration - Extending the Model

This chapter presents an extension of the model introduced in Chapter 3. More specifically, we allow for return migration and for partially portable human capital when living abroad. In addition, we introduce more structure to the productivity shocks experienced by agents born in P and allow for the possibility that agents may draw such shocks from a different stochastic process when living in their home country versus when living abroad. The sections of this chapter are organized in a similar way to those of Chapter 3, and the chapter is presented as a standalone paper with a lot of the same language as Chapter 3. We have added language as needed throughout the chapter to highlight any significant departure points.

4.1 Environment

Same as in Chapter 3, the economy is a discrete-time economy consisting of two countries, denoted by R and P. Every period, an equal measure of agents is introduced to the economy of both countries. Agents in both countries make decisions in the economy for a finite number of periods, that we represent by T and then retire. We assume for simplicity that neither country R nor country P experiences demographic changes so that the measure of agents introduced in each country is constant over time. An agent's number of periods spent in the economy will be referred to as the agent's "age". Agents in each country are heterogeneous in that when they are introduced to the economy they have different levels of human capital endowment. Agents born in $i \in \{R, P\}$ are introduced to the economy with a human capital endowment h_o^i drawn from a country-specific probability distribution and with no physical capital.

Same as in Chapter 3, in each period, agents consume, accumulate physical and human capital, and supply labor inelastically. An agent of age τ has preferences over the consumption good characterized by a continuous, increasing, strictly concave utility function $u(c_\tau)$ and discounts future consumption at a rate $\beta \in (0,1)$. Physical capital is perfectly mobile so that agents in each country are able to trade ownership claims to physical capital located in any of the two countries. As such, physical capital earns the same rate of return in the two countries. For each unit of capital purchased at time t agents will receive $1 + r_{t+1}$ units at time $t+1$. Agents can also invest in human capital. Human capital is directly tradeable for consumption and its level evolves according to $h_{\tau+1} = (1-\delta_h)h_\tau + i_\tau$, where h_τ is the level of human capital of an agent of age τ, i_τ is the investment in human capital, and $\delta_h \in (0,1)$ is the depreciation rate of human capital.

In addition to making consumption, human capital, and physical capital decisions in every period, agents born in P can also decide whether or not to migrate, if they started the period in P, or return migrate, if they had migrated earlier in their life and wish to return to R. Agents born in R on the other hand are unable to migrate to P. Agents born in P who choose to emigrate to R need to pay a fixed cost $\phi > 0$ upon arriving in their new country. For simplicity, it is assumed that ϕ does not depend on the agent's age or human capital. It is also assumed that agents who move back to their country of birth P may do so at no cost. Agents of age $\tau \in \{0, 1, 2, \ldots, T\}$ that are born in R and have human capital h_τ supply a labor amount given by

$l_\tau^R = h_\tau^\alpha$. Agents born in P who live in P supply a labor amount given by $l_\tau^P = zh_\tau^\alpha$. Unlike in Chapter 3, where we assumed that agents born in P were able to carry over all of their human capital with them when relocating to R, in this chapter we assume that agents born in P who live in R experience a downgrade in the level of human capital that they can use in R. This downgrade in human capital has been shown extensively in the existing immigration literature and is due to factors such as language difficulties, education quality differences and formal recognition rules to foreign education credentials. The supply of labor services for these agents is given by $l_\tau^R = z_\tau(\theta h_\tau)^\alpha$, where $\theta \leq 1$ represents the fraction of human capital that can be used in country R. We assume for simplicity that θ is the same across agents and does not depend on age or the number of periods spent abroad. Same as in Chapter 3, the constant $\alpha < 1$ is the same across all agents regardless of age or country of birth.

An important departure of the model in this chapter from the one presented in Chapter 3, is that unlike in Chapter 3, where the productivity shock z_τ was modeled based on draws from a Binomial Distribution, with workers being 80 percent productive half of the time and 100 percent productive the other half, in this chapter the productivity shock z_τ is set to follow an AR(1) process given by the following:

$$z_\tau = e^{x_\tau} \tag{4.1}$$

where x evolves according to

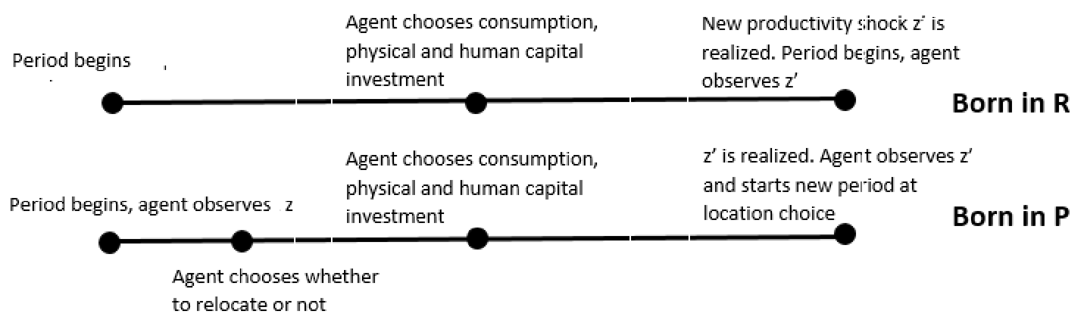
$$x_\tau = \rho x_{\tau-1} + \epsilon_\tau \tag{4.2}$$

where the autocorrelation parameter $\rho \in (0, 1)$ is country-specific and ϵ_τ is independently and identically drawn from a truncated normal distribution.

Finally, in each country there is a competitive firm that transforms capital and labor into output according to a the production function given by $Y_t^i = A^i G(K_t^i, L_t^i)$ where $i \in \{R, P\}$ represents the country and $t \in \mathbb{N}$ represents time. A^i is the exogenously given TFP while K_t^i and L_t^i are, respectively, the aggregate physical capital and labor employed in production.[1]

4.2 Timing

Timing is similar as in Chapter 3 and is illustrated in the diagram below. Agents born in R do not experience any productivity shocks. Agents born in P observe the current-period productivity shock at the beginning of the period. Then they make their next period's consumption and investment decisions. In addition, agents born in P decide, at the beginning of every period, whether or not to relocate. If they decide to relocate, they have to pay all associated costs at the end of the period and begin the next period in their new location. If they decide to remain, they don't have to pay any relocation costs, and begin their next period in the same country.



4.3 Agents' problems

In this section we present the problems faced by agents born in R and P recursively. Same as in Chapter 3, we have assumed that agents born in R cannot relocate to P, so their problem is more straightforward. Such agents are characterized by age, human capital, and assets. Letting $V_\tau^R(h, a)$ represent the lifetime expected utility of this agent and w_R the wage rate paid by the firm in R, the problem can be written

[1]Note that the subscript t represents the time since the economy began and not the age of any living agent. In this chapter, the latter is represented by a τ subscript

recursively as:

$$\begin{aligned} V_\tau^R(h,a) = \max_{c,h',a'} \quad & \left\{ u(c) + \beta V_{\tau+1}^R(h',a') \right\} \\ \text{s.t.} \quad & c + i + a' = a(1+r) + h^\alpha w_R \\ & i = h' - (1-\delta_h)h \\ & a \geq 0, \quad i \geq 0 \end{aligned} \tag{4.3}$$

Agents born in R receive income from assets purchased in the previous period and from working for the firm. This income is used to purchase consumption, new assets, and additional human capital. Through $a \geq 0$, we have assumed for simplicity that agents cannot borrow physical assets. Alternative specifications include introducing a borrowing limit on assets, representing the agents' ability to borrow in financial markets. The other constraint, $i \geq 0$ represents the natural assumption around human capital as the type of capital that can be traded back in exchange for consumption goods only by converting into labor.

When choosing consumption, future assets, and human capital, agents of age $\tau = T$ face the terminal value function given by:

$$V_{T+1}^R(h,a) = 0, \quad \text{for all} \quad (h,a) \in \mathbb{R}_+^2.$$

This terminal value function weakens the incentives to invest in human and physical capital as agents get older and ensures that in their last period of life they will consume all their income. Alternative specifications where agents face a terminal value that is linear in physical capital add computational complexity while providing no significant added insight or materially changing the results presented in this chapter. As such, we use a zero terminal value specification such as the one presented above.

Agents born in P are characterized by age, human capital stock, level of assets, productivity, and current residence. The problem solved by agents starting the period in their country of birth P is similar to the one presented in Chapter 3 and is shown below:

$$\begin{aligned}
V_\tau^{PP}(h,a,z) = \max_{c,h',a',m_R} \quad & \Big\{u(c) + \beta\Big[m_R E\big[V_{\tau+1}^{PR}(h',a'-\phi,z')\big] + \\
& (1-m_R)E\big[V_{\tau+1}^{PP}(h',a',z')\big]\Big]\Big\} \\
\text{s.t.} \quad & c + i + a' = a(1+r) + w_P z h^\alpha \\
& i = h' - (1-\delta_h)h \\
& a' - m_R\phi \geq 0, \quad i \geq 0 \\
& m_R \in \{0,1\}
\end{aligned} \tag{4.4}$$

Here $V_\tau^{PP}(h,a,z)$ represents the expected lifetime utility and m_R represents the decision to migrate to R. Since the agent pays the fixed migration costs upon arriving in R, if the agent migrates to R her next period's expected lifetime utility is given by $V_{\tau+1}^{PR}(h',a'-\phi,z')$. The value function $V_\tau^{PR}(h,a,z)$ represents the problem solved by the agent born in P who lives in R. Its general form is given given recursively by:

$$\begin{aligned}
V_\tau^{PR}(h,a,z) = \max_{c,h',a',m_R} \quad & \Big\{u(c) + \beta\Big[m_P E\big[V_{\tau+1}^{PP}(h',a',z')\big] + \\
& (1-m_P)E\big[V_{\tau+1}^{PR}(h',a',z')\big]\Big]\Big\} \\
\text{s.t.} \quad & c + i + a' = a(1+r) + w_R z (\theta h)^\alpha \\
& i = h' - (1-\delta_h)h \\
& a' \geq 0, \quad i \geq 0 \\
& m_P \in \{0,1\}
\end{aligned} \tag{4.5}$$

Unlike in Chapter 3 where it was assumed that agents born in P who migrate to R stay there and can not return to P, in Chapter 4 we allow for return migration. This decision is captured by m_P, which represents the choice variable of the agent that can return to P. Since return migration entails no cost, the no borrowing constraint for this agent is given by $a' \geq 0$. Finally, agents born in P who live at home or abroad face terminal value functions given by:

$$V_{T+1}^{PP}(h,a,z) = V_{T+1}^{PR}(h,a,z) = 0, \quad \text{for all} \quad (h,a,z) \in \mathbb{R}_+^2 \times Z$$

4.4 Firms' problem

Firms' problem is identical to the one in Chapter 3, and is shown below.

$$\max_{K^i,L^i} \left\{ A^i G(K^i, L^i) - rK^i - w_i L^i - \delta_k K^i \right\} \tag{4.6}$$

where δ_k is the depreciation rate of physical capital.

4.5 Stationary Equilibrium

Let $S_R = \mathbb{R}_+^2$ be the state space for the agent born in R and $S_P = \mathbb{R}_+^2 \times Z$ be the state space for the agent born in P. A stationary equilibrium consists of

1. Interest rate r and wages w_R, w_P

2. Value functions for all types of agents at every age

   $V_\tau^{PP} : S_P \to \mathbb{R}_+$, $V_\tau^{PR} : S_P \to \mathbb{R}_+$, $V_\tau^R : S_R \to \mathbb{R}_+$;

3. Policy functions for all types of agents at every age

   $c_\tau^{PP} : S_P \to \mathbb{R}_+$, $g_{a,\tau}^{PP} : S_P \to \mathbb{R}_+$, $g_{h,\tau}^{PP} : S_P \to \mathbb{R}_+$, $m_{R,\tau} : S_P \to \{0,1\}$
   $c_\tau^{PR} : S_P \to \mathbb{R}_+$, $g_{a,\tau}^{PR} : S_P \to \mathbb{R}_+$, $g_{h,\tau}^{PR} : S_P \to \mathbb{R}_+$, $m_{P,\tau} : S_P \to \{0,1\}$
   $c_\tau^R : S_R \to \mathbb{R}_+$, $g_{a,\tau}^R : S_R \to \mathbb{R}_+$, $g_{h,\tau}^R : S_R \to \mathbb{R}_+$;

4. Distributions of agents

   $\lambda_\tau^R(h,a)$, $\lambda_\tau^{PP}(h,a,z)$, $\lambda_\tau^{PR}(h,a,z)$

so that

1. Given r and w_R, agent born in R chooses value functions V_τ^R and policies $c_\tau^R, g_{a,\tau}^R, g_{h,\tau}^R$ to solve the problem given in (4.3).

2. Given r and w_R, w_P, agent born in P who lives at home chooses value functions V_τ^{PP} and policies $c_\tau^{PP}, g_{a,\tau}^{PP}, g_{h,\tau}^{PP}, m_{R,\tau}$ to solve the problem given in (4.4).

3. Given r and w_R, w_P, agent born in P who lives abroad chooses value functions V_τ^{PR} and policies $c_\tau^{PR}, g_{a,\tau}^{PR}, g_{h,\tau}^{PR}, m_{P,\tau}$ to solve the problem given in (4.5).

4. Wages and interest rates are given by marginal products

$$\begin{aligned} w_R &= A_R G_2(K_R, L_R) \\ w_P &= A_P G_2(K_P, L_P) \\ r &= A_i G_1(K_i, L_i) - \delta_k \end{aligned} \tag{4.7}$$

5. Aggregation of capital and labor follows from the policy functions and the distributions $\lambda_\tau^R, \lambda_\tau^{PP}, \lambda_\tau^{PR}$

$$\begin{aligned} K^R + K^P &= \sum_{\tau=1}^{T} \Big[\int_{S_R} g_{a,\tau}^R(h,a) d\lambda_\tau^R(h,a) + \int_{S_P} g_{a,\tau}^{PP}(h,a,z) d\lambda_\tau^{PP}(h,a,z) \\ &\quad + \int_{S_P} g_{a,\tau}^{PR}(h,a,z) d\lambda_\tau^{PR}(h,a,z) \Big] \\ L^P &= \sum_{\tau=1}^{T} \Big[\int_{S_P} z h^\alpha d\lambda_\tau^{PP}(h,a,z) \Big] \\ L^R &= \sum_{\tau=1}^{T} \Big[\int_{S_P} z(\theta h)^\alpha d\lambda_\tau^{PR}(h,a,z) + \int_{S_R} h^\alpha d\lambda_\tau^R(h,a) \Big] \end{aligned} \tag{4.8}$$

6. If Q is the law of motion between states induced by policy functions and stochastic kernels, then the distribution λ satisfies: [2]

$$Q \circ \lambda = \lambda \tag{4.9}$$

[2] A formal definition of Q is presented in the appendices

4.6 Calibration and Results

Same as in Chapter 3, we have calibrated agent and firm specific characteristics using parameters that are standard in the literature. Parameters in connection with R and P are chosen based on U.S. and RoW data, so that most of the parameters selected are the same as those used in Chapter 3. See footnote in Section 3.6 of Chapter 3 for the relevant assumption around RoW economies. Same as in Chapter 3, the fixed cost ϕ that agents born in P incur in connection with their relocation to country R is calibrated within the model so that in equilibrium, P-born agents living in R account for 21.0 percent of the total measure of agents living in R, which is consistent with the data. Below we summarize the parameters selected

4.6.1 Environment

The total number of periods that agents in each economy live is chosen to be $T = 45$, to capture the number of years individuals typically make decisions and work for before they retire.

4.6.2 Agents - Preferences

A utility discount factor $\beta = 0.96$ is chosen to align with the standard intertemporal discounting that is used in much of the macroeconomic literature. A standard CRRA utility function $u(c) = (c^{1-\sigma})/(1-\sigma)$ with a coefficient of relative risk aversion aversion $\sigma = 2$ is used to capture agent's preferences for this exercise. The assumption is standard in much of the macroeconomics literature.

4.6.3 Agents - Human Capital

Agents in R and P are introduced to the economy with varying levels of human capital. Same as in Chapter 3, we are assuming that the initial level of human capital h_o^i is drawn from a lognormal distribution with parameters $\mathcal{N}(\mu_i, \sigma_i^2)$. The moments of human capital have been calibrated so that the youngest cohort's average human capital in R is 56.38 percent higher than in the youngest cohort's average human capital in P, while keeping the variances of the log-normal distribution the same across the two countries. As is standard in the literature, the coefficient of labor with respect to human capital α is assumed to be 0.85. Finally, we have selected the coefficient $\theta = 0.8$ which means that agents born in P are only able to use 80 percent of their human capital when living in R. This level is consistent with several estimates in the immigration literature.[3]

4.6.4 Agents - Productivity

Agents born in P are subject to productivity shocks so that the labor they supply is given by $l_\tau^P = zh_\tau^\alpha$. While in Chapter 3 it was assumed that z is independently and identically drawn from a Binomial distribution with a country-invariant productivity parameter $p = 0.50$, in this chapter we are allowing the productivity shock z to be governed by the AR(1) process shown below.

$$z_\tau = e^{x_\tau} \tag{4.10}$$

where x evolves according to

$$x_\tau = \rho x_{\tau-1} + \epsilon_\tau \tag{4.11}$$

Following Heathcote and Violante. (2010) we have set the autocorrelation parameter ρ to 0.97. We have allowed for the possibility of that the ϵ innovations are more volatile in P than in R and have set the variance of ϵ to be equal to 0.01 if the agent lives in P and 0.03 if the agent lives in R.

[3] See the estimates in Borjas (1996) and Hendricks and Schoellman (2016) and the survey of the literature in Akresh (2008).

4.6.5 Firms - Production

Output in each country is produced according to a Cobb-Douglas production function $A^i(K^i)^{(1-\nu)}(L^i)^{\nu}$, where ν and $1-\nu$ are the labor and capital shares respectively. Karabarbounis and Neiman (2013) document a significant decline in labor share globally since the early 1980s, roughly half of which can be explained by the lower relative price of investment goods. Their estimates of the most recent share of output attributable to labor is approximately 59 percent. As such, we have selected $\nu = 0.59$.

Using Penn World Table 2017 TFP data we have estimated that the population-weighted PPP-adjusted TFP of RoW countries is about 2.32 times lower than that of the United States. As such we have used the normalization $A_P = 1$ and have set A_R to be equal to 2.32.

4.6.6 Relocation Costs

Same as in Chapter 3, we have calibrated the relocation costs ϕ to match the moments from U.S. immigration data. More specifically, we have targeted a 48 percent share of arrivals to R before the age of 30, which is consistent with current immigration trends in the U.S. An alternative calibration where ϕ is chosen so that the model-generated measure of agents born in P who live in R as a fraction of the total measure of agents that live in R in the stationary equilibrium matches the share of the total foreign-born population in the U.S. yields results that are qualitatively similar.

4.6.7 Stationary Equilibrium results

The parameters chosen to calibrate the stationary equilibrium of the extended model are summarized in Table A.4. In this section we discuss certain observations with respect to the stationary equilibrium, while the policy experiment results are discussed in Section 4.7 below.

In the stationary equilibrium, the distribution of human capital among agents of the youngest cohort will reflect their draw of h_o^R or h_o^P, which is one of the sources of agent heterogeneity in our model. This is shown in Figure D.2. While same as in Chapter 3 the model exhibits no immigration among agents of the youngest cohorts given that agents are born with no physical capital and relocation requires liquidating some physical assets on the front end, compared to the distribution observed in the stationary equilibrium of Chapter 3, immigration in the stationary equilibrium of the extended model starts ramping up earlier among younger cohorts, a pattern that indicates the increased heterogeneity among agents born in P in the extended model because of the more varied structure of the productivity shocks. The distribution of P-born agents in R for each age group is shown in Figure D.9 while Figure D.10 shows the pattern of new arrivals to R by agents born in P.

Agents born in R start out at a higher level of human capital due to their favorable draw, so they continue to own more human capital than immigrants in R for a number of years until both groups eventually hit a satiation point after which both groups own the same level of human capital. The average human capital held by agents born in R and by those born in P living in R for each age group is shown in Figure D.11. Same as in Chapter 3, given immigration among agents of younger cohorts is low, certain agents in the younger cohorts with a relatively large draw of initial human capital, are able to use their labor income to purchase physical capital early in their lives, which will then allow them to relocate to R. As such, the average physical capital of this selected group exceeds that of agents born in R. Once in R these agents are able to receive the higher w_R wage level, which lowers their incentive to quickly accumulate physical capital as the relative importance of investing in human capital becomes larger. This is reflected in the lower level of physical assets compared to agents that live in R as shown in Figure D.12.

4.7 Policy Experiment

Same as in Chapter 3, our policy experiment exercise will assume that country R only allows the immigration of agents bringing a human capital level above a certain threshold ζ, determined in relation to the average human capital of native born workers, with them. Other agents are unable to relocate for that period, but may do so in later periods of their life. The range of ζ values we have chosen for this exercise is characterized by the equation below:

$$\zeta e^{-(\mu_R + \frac{\sigma_R^2}{2})} - 1 = \kappa$$

where are the parameters characterizing the log-normal distribution from which the initial human capital for the youngest cohort of agents born in R is drawn from. For the purposes of this exercise, we are choosing a ζ-threshold so that in the new counterfactual policy, only potential workers who have human capital levels at least 20 percent larger than the average human capital level of the 20-year old native worker are able to relocate.

The problem of the agent born in P who lives at home will now be

$$V_\tau^{PP}(h,a,z) = \begin{cases} \tilde{V}_\tau^{PP}(h,a,z) & \text{if} \quad h < \zeta \\ \hat{V}_\tau^{PP}(h,a,z) & \text{if} \quad h \geq \zeta \end{cases} \tag{4.12}$$

where $\hat{V}$ and $\tilde{V}$ are given by

$$\begin{aligned} \hat{V}_\tau^{PP}(h,a,z) = \max_{c,h',a',m_R} \quad & \Big\{ u(c) + \beta \Big[m_R E\big[V_{\tau+1}^{PR}(h', a'-\phi, z')\big] + \\ & (1-m_R) E\big[V_{\tau+1}^{PP}(h',a',z')\big]\Big]\Big\} \\ \text{s.t.} \quad & c + i + a' = a(1+r) + zh^\alpha w_P \\ & i = h' - (1-\delta_h)h \\ & a' \geq 0, \quad i \geq 0 \\ & m_R \in \{0,1\} \end{aligned} \tag{4.13}$$

and

$$\begin{aligned}
\tilde{V}_{\tau}^{PP}(h,a,z) = \max_{c,h',a',m_R} \quad & \Big\{u(c) + \beta E\Big[V_{\tau+1}^{PP}(h',a',z')\Big]\Big\} \\
\text{s.t.} \quad & c + i + a' = a(1+r) + h^{\alpha} w_P \\
& i = h' - (1-\delta_h)h \\
& a' \geq 0, \quad i \geq 0
\end{aligned} \tag{4.14}$$

4.8 Comparison of Stationary Equilibria

Table A.6 summarizes our results from comparing the stationary equilibria for our extended model. Same as with the model in Chapter 3, we observe that the impact of the change in policy on prices and macroeconomic aggregates is small. Results suggest a negligible impact on wage rates in both countries. The level of aggregate physical and human capital in P experiences a significant increase, though the increase in the average physical and human capital (defined as aggregate human or physical capital divided by the measure of agents in P in the stationary equilibrium) is 5.45 and 6.41 percent respectively.

The measure of agents born in P who live in R, denoted by M and defined as:

$$M = \sum_{\tau=1}^{T} \Big[\int_{S_P} d\lambda_{\tau}^{PR}(h,a,z)\Big]$$

is reduced in the long-run by 5.06, a result that is similar in both magnitude and direction to the result obtained in Chapter 3. Therefore, the counterfactual policy that only allows agents with 20 percent more human capital than the average level of human capital among young natives to immigrate to R leads to modest changes in wage levels and output per capita in both countries and at the same time reduces the number of P born agents in R.

Chapter 5

Conclusion and Discussion

Chapters 3 and 4 of this dissertation quantify the likely impact of an immigration policy that only allows agents that have levels of human capital above a certain threshold to immigrate. We have built a two-country, general equilibrium, heterogeneous agent model that features human capital accumulation and endogenous migration decisions. In the model migration emerges naturally from the difference in wage rates between the two countries and occurs in larger numbers as agents accumulate more physical and human capital. There are two main findings. First, prices and aggregate quantities in the two countries will adjust in a way that reflects modest long-run increases in wages and modest increases in output per capita. As discussed in Chapters 3 and 4, results are robust to several alternative model specifications. Second, allowing only agents who have invested in human capital to immigrate to R will bring about a more significant reduction in the measure of immigrants in the long-run. The added incentive to rapidly accumulate human capital early in life in order to be able to emigrate is not sufficiently high in equilibrium as to overcome the opportunity cost of investing today's income on physical capital.

Several important considerations are abstracted from in this dissertation. First, the analysis presented does not account for any effects that immigrant networks may have on potential immigrants and their job prospects in the receiving country. To the extent that such networks strengthen the incentive to immigrate, the model will underestimate the effects of any labor movement restrictions. Second, it ignores externalities related to immigration. More specifically, we have not modelled any changes in firm productivity that may arise due to changes in the skill composition of immigrants, though such changes are likely to occur. We also abstract from any discussion of public goods and how immigrants and natives share the responsibility of providing them. Finally, the endogenous migration decisions in the model are not reflections of concerns over the welfare of the progeny. To the extent that intergenerational altruism is strong, the effects of any labor movement restrictions will be overestimated in the model presented in this dissertation.

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Appendix A

Tables

A.1 Chapter 3 Tables

Table A.1: Parameter Values

Parameter	Description	Value
σ	coeff. of relative risk aversion	2
T	agent lifespan (periods)	47
β	discount factor	0.96
α	labor elasticity wrt human capital	0.85
ν	labor share	0.59
(μ_R, σ_R)	moments of initial human cap. (R)	(2, 0.2)
(μ_P, σ_P)	moments of initial human cap. (P)	(1.525, 0.308)
(δ_k, δ_h)	depreciation	(0.1, 0.15)
(A^R, A^P)	TFPs	(2.32, 1)

Table A.2: Policy Experiment Scenarios

Specification	κ - parameter
(1)	20.0%
(2)	50.0%

Table A.3: Comparison of Stationary Equilibria

Variable	Description	Change (1)	Change (2)
w_R	wage rate in R	0.19% $\uparrow$	0.43% $\uparrow$
w_P	wage rate in P	0.19% $\uparrow$	0.43% $\uparrow$
K^R	capital in R	0.19% $\downarrow$	0.41% $\downarrow$
K^P	capital in P	4.76% $\uparrow$	8.90% $\uparrow$
k^R	avg. capital in R	1.17% $\uparrow$	2.28% $\uparrow$
k^P	avg. capital in P	2.06% $\uparrow$	3.56% $\uparrow$
y_R	output per capita in R	0.89% $\uparrow$	1.64% $\uparrow$
y_P	output per capita in P	1.81% $\uparrow$	2.98% $\uparrow$
M	immigrant population in R	5.50% $\downarrow$	10.73% $\downarrow$
H^R	human capital in R	0.66% $\downarrow$	1.47% $\downarrow$
H^P	human capital in P	4.68% $\uparrow$	8.48% $\uparrow$
h^R	avg. human capital in R	0.70% $\uparrow$	1.19% $\uparrow$
h^P	avg. human capital in P	2.00% $\uparrow$	3.18% $\uparrow$

A.2 Chapter 4 Tables

Table A.4: Parameter Values

Parameter	Description	Value
σ	coeff. of relative risk aversion	2
T	agent lifespan (periods)	45
β	discount factor	0.96
α	labor elasticity wrt human capital	0.85
ν	labor share	0.59
θ	fraction of portable human capital	0.80
ρ	autocorrelation coefficient	0.97
$(\sigma^2_{\epsilon,P}, \sigma^2_{\epsilon,R})$	variance of ϵ $(P,\ R)$	(0.01, 0.03)
(δ_k, δ_h)	depreciation	(0.10, 0.15)
(μ_R, σ_R)	moments of initial human cap. (R)	(2, 0.2)
(μ_P, σ_P)	moments of initial human cap. (P)	(1.525, 0.308)
(A^R, A^P)	TFPs	(2.32, 1)

Table A.5: Policy Experiment Scenarios

Specification	κ - parameter
(1)	20.0%

Table A.6: Comparison of Stationary Equilibria

Variable	Description	Change (1)
w_R	wage rate in R	0.01% $\downarrow$
w_P	wage rate in P	0.01% $\downarrow$
K^R	capital in R	1.22% $\downarrow$
K^P	capital in P	36.03% $\uparrow$
k^R	avg. capital in R	1.13% $\uparrow$
k^P	avg. capital in P	5.45% $\uparrow$
y_R	output per capita in R	1.14% $\uparrow$
y_P	output per capita in P	5.46% $\uparrow$
M	immigrant population in R	5.06% $\downarrow$
H^R	human capital in R	1.20% $\downarrow$
H^P	human capital in P	37.27% $\uparrow$
h^R	avg. human capital in R	1.15% $\uparrow$
h^P	avg. human capital in P	6.41% $\uparrow$

Appendix B

Algorithm to calculate Stationary Equilibrium

The algorithm used in calculating the stationary equilibrium for the model presented in this paper is presented below:

1. Guess a level for aggregate capital $K = K_R + K_P$ and aggregate labor in each country L_R, and L_P.

2. Use the three equations below to solve for r, K_R and K_P.

$$\begin{aligned} r &= A_P G_1(K_P, L_P) - \delta_k \\ r &= A_R G_1(K_R, L_R) - \delta_k \\ K &= K_R + K_P \end{aligned} \tag{B.1}$$

3. Calculate wages w_R and w_P using the two equations below

$$\begin{aligned} w_P &= A_P G_2(K_P, L_P) \\ w_R &= A_R G_2(K_R, L_R) \end{aligned} \tag{B.2}$$

4. Use wages and interest rates calculated above as wells as the terminal values $V_T^R = V_T^{PP} = V_T^{PR} = 0$ to calculate optimal policies and value functions for

agents of age $T-1$. Proceed using these functions to calculate policies and value functions for agents of age $T-2$, etc.

5. Calculate the stationary distribution associated to these prices, optimal policies, and value functions (see next Section)

6. Given the stationary distribution of agents across states calculate aggregate capital and aggregate labor in R and P.

7. If these values are sufficiently close to the guessed levels for aggregate capital and aggregate labor in each country a stationary equilibrium has been found, if not update the guesses to the values found in 6. and proceed with 2.

A grid of 50 points for the human capital state space and 100 points for the asset space is used to calculate optimal policies and value functions. The algorithm above is implemented in Python 2.7 and each iteration takes about 1,260 seconds.

Appendix C

Law of motion between states

Define $X \equiv \{\text{R, PP, PR}\} \times \{0, 1, 2, \ldots, T\} \times \mathbb{R}^2_+$ where the first set in the Cartesian product represents the set of agent types, the second represents the set of different ages and the third, the set of human capital - physical capital combinations. Let $Z \equiv Z_R \cup Z_P$ represent the joint set of productivity shocks. Then all agents in this model are characterized by an element of X and an element of Z. Define the state-space as $S \equiv X \times Z$ with the Borel σ-algebra $\mathcal{S}$ and typical subset $(\mathcal{X} \times \mathcal{Z})$. The space $(S, \mathscr{S})$ is measurable and for any $\mathcal{S} \in \mathscr{S}$, we will denote by $\lambda(\mathcal{S})$ the probability measure that represents the fraction of agents in the set $\mathcal{S}$.

Define $\pi((x, z), \mathcal{X} \times \mathcal{Z})$ to be the probability that an agent with current state (x, z) transitions to the set $\mathcal{X} \times \mathcal{Z}$ in the next period. Formally, $\pi : S \times \mathscr{S} \to [0, 1]$, and

$$\pi((x, z), \mathcal{X} \times \mathcal{Z}) \equiv \int_{z' \in Z} \mathbb{I}\{x'(x, z) \in \mathcal{X}\} \cdot f(z', z) \tag{C.1}$$

where $\mathbb{I}$ is an indicator function and a' and f are defined below. Notice that since in the mode agents born in P who migrate or return migrate switch to a different productivity shock regime, for these agents $f(z', z)$ will be defined implicitly as a function of $x'(x, z)$.

For $(x, z) = (R, \tau, h, a, z)$ it follows that

$$x'(R, \tau, h, a, z) = \begin{cases} (R, \tau+1, g^R_{h,\tau}(h, a, z), g^R_{a,\tau}(h, a, z)) & \text{if } \tau < T \\ (R, 0, h^R_o, 0) & \text{if } \tau = T \end{cases} \tag{C.2}$$

and

$$f(z', z) = \begin{cases} dF(z') & \text{if } z' \in Z_R \text{ and } \tau < T \\ 1 & \text{if } z' \in Z_R,\ \tau = T \text{ and } z' = z^R_o \\ 0 & \text{otherwise} \end{cases} \tag{C.3}$$

For $(x, z) = (PP, \tau, h, a, z)$ it follows that

$$x'(PP, \tau, h, a, z) = \begin{cases} (PP, \tau+1, g^{PP}_{h,\tau}(h, a, z), g^{PP}_{a,\tau}(h, a, z)) & \text{if } \tau < T \text{ and } m_{R,\tau} = 0 \\ (PR, \tau+1, g^{PP}_{h,\tau}(h, a, z), g^{PP}_{a,\tau}(h, a, z)) & \text{if } \tau < T \text{ and } m_{R,\tau} = 1 \\ (PP, 0, h^P_o, 0) & \text{if } \tau = T \end{cases} \tag{C.4}$$

and

$$f(z', z) = \begin{cases} \Gamma_R(z'|z) & \text{if } z' \in Z_P,\ \tau < T \text{ and } m_{R,\tau} = 1 \\ \Gamma_P(z'|z) & \text{if } z' \in Z_P,\ \tau < T \text{ and } m_{R,\tau} = 0 \\ 1 & \text{if } z' \in Z_P,\ \tau = T \text{ and } z' = z^P_o \\ 0 & \text{otherwise} \end{cases} \tag{C.5}$$

Finally, for $(x, z) = (PR, \tau, h, a, z)$ it follows that

$$x'(PR, \tau, h, a, z) = \begin{cases} (PR, \tau+1, g^{PR}_{h,\tau}(h, a, z), g^{PR}_{a,\tau}(h, a, z)) & \text{if } \tau < T \text{ and } m_{P,\tau} = 0 \\ (PP, \tau+1, g^{PR}_{h,\tau}(h, a, z), g^{PR}_{a,\tau}(h, a, z)) & \text{if } \tau < T \text{ and } m_{P,\tau} = 1 \\ (PP, 0, h^P_o, 0) & \text{if } \tau = T \end{cases} \tag{C.6}$$

and

$$f(z', z) = \begin{cases} \Gamma_P(z'|z) & \text{if } z' \in Z_P,\ \tau < T \text{ and } m_{P,\tau} = 1 \\ \Gamma_R(z'|z) & \text{if } z' \in Z_P,\ \tau < T \text{ and } m_{P,\tau} = 0 \\ 1 & \text{if } z' \in Z_P,\ \tau = T \text{ and } z' = z_o^P \\ 0 & \text{otherwise} \end{cases} \tag{C.7}$$

Given an arbitrary measure $\lambda : \mathscr{S} \to [0, 1]$, the operator Q, introduced in Chapters 3 and 4, is formally defined as

$$(Q \circ \lambda)(\mathcal{X} \times \mathcal{Z}) = \int_{X \times Z} \pi((x, z), \mathcal{X} \times \mathcal{Z}) d\lambda(x, z) \tag{C.8}$$

The stationary measure λ^* needs to satisfy

$$(Q \circ \lambda^*)(\mathcal{X} \times \mathcal{Z}) = \lambda^*(\mathcal{X} \times \mathcal{Z}),\ \forall \mathcal{X} \times \mathcal{Z} \in \mathscr{S} \tag{C.9}$$

Appendix D

Figures

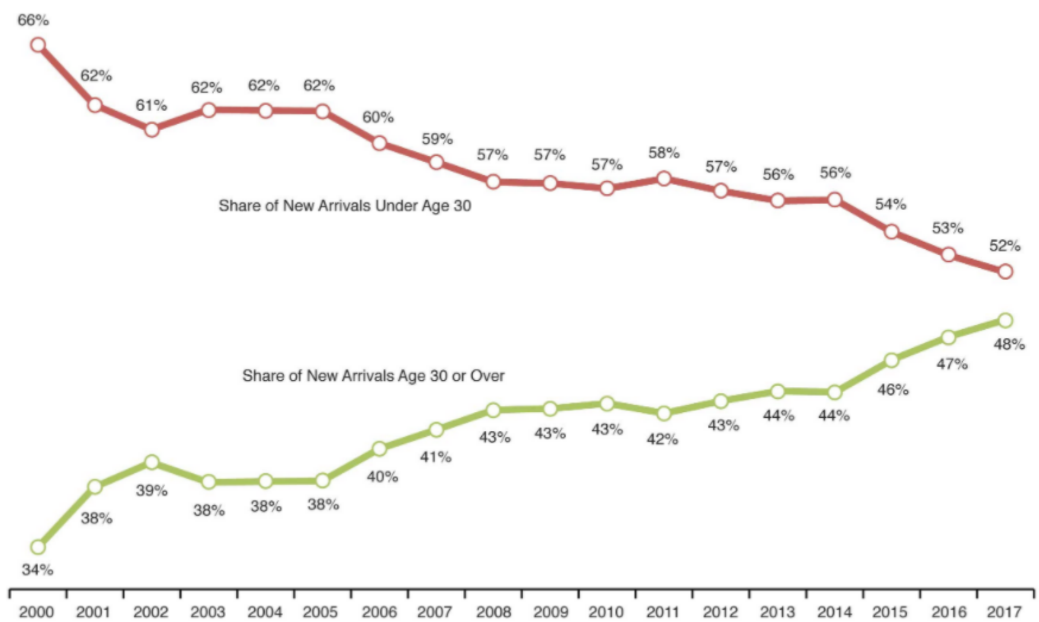

Figure D.1: U.S. Immigration Data - Share of Arrivals by Age Group

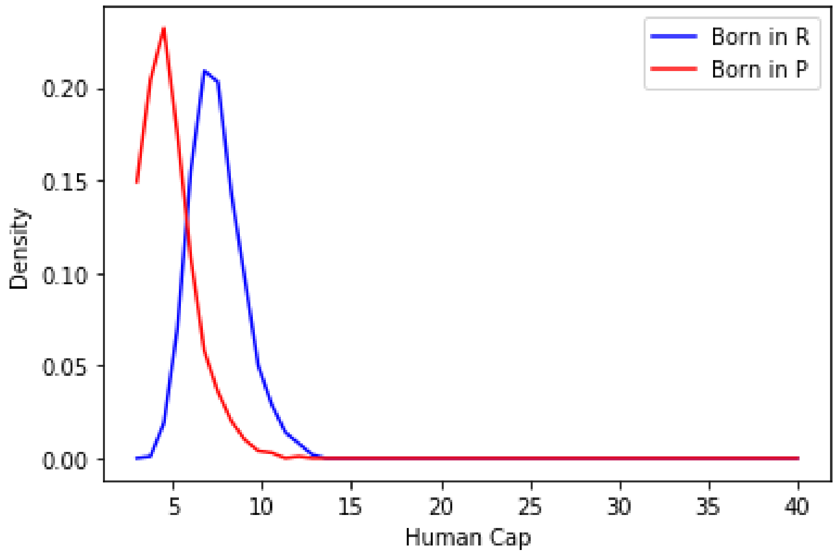

Figure D.2: Agent heterogeneity with respect to initial human capital

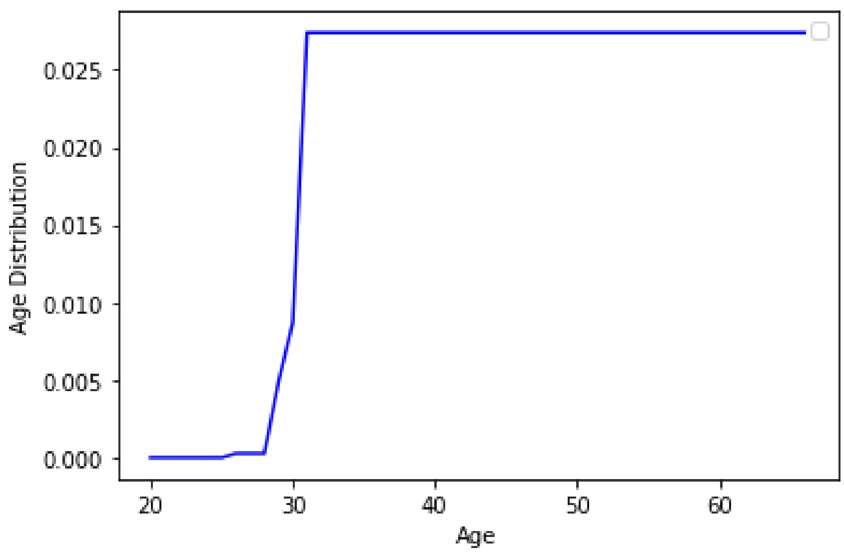

Figure D.3: Age Distribution of Immigrants in R

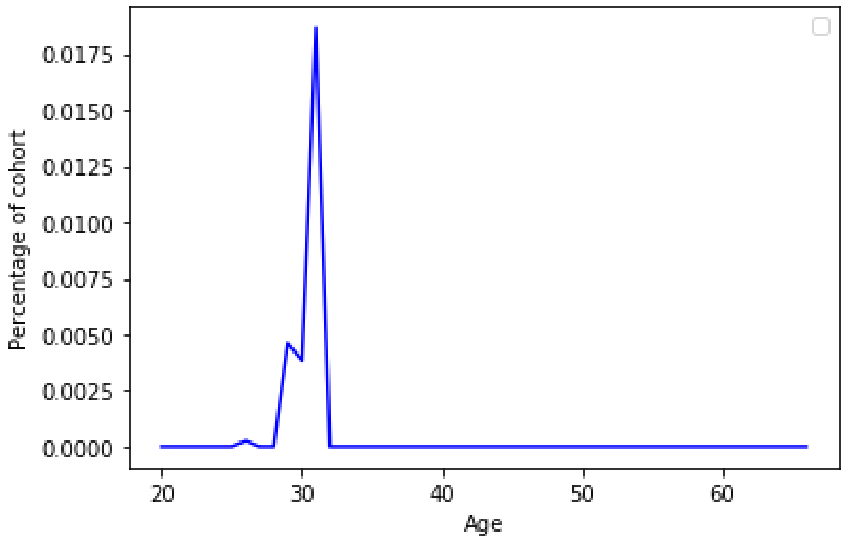

Figure D.4: Age of Relocation to R

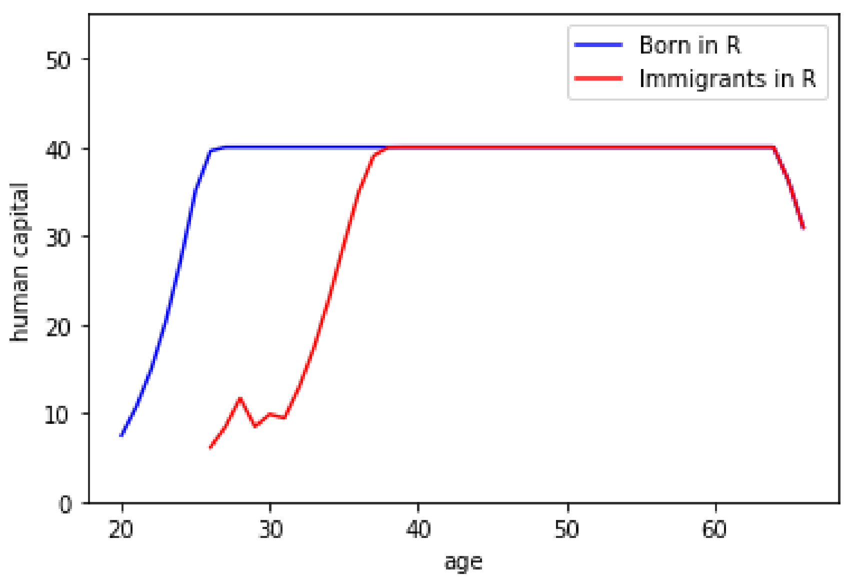

Figure D.5: Human Capital by Age

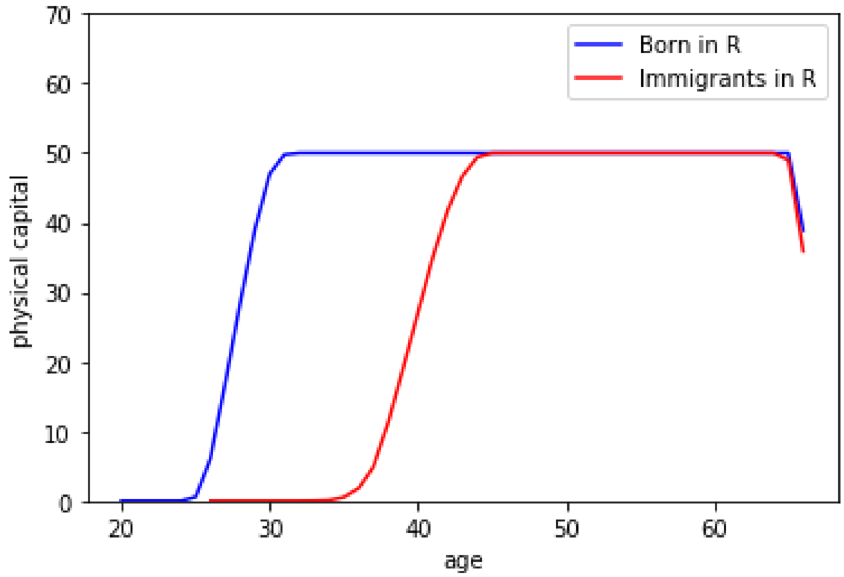

Figure D.6: Physical Capital by Age

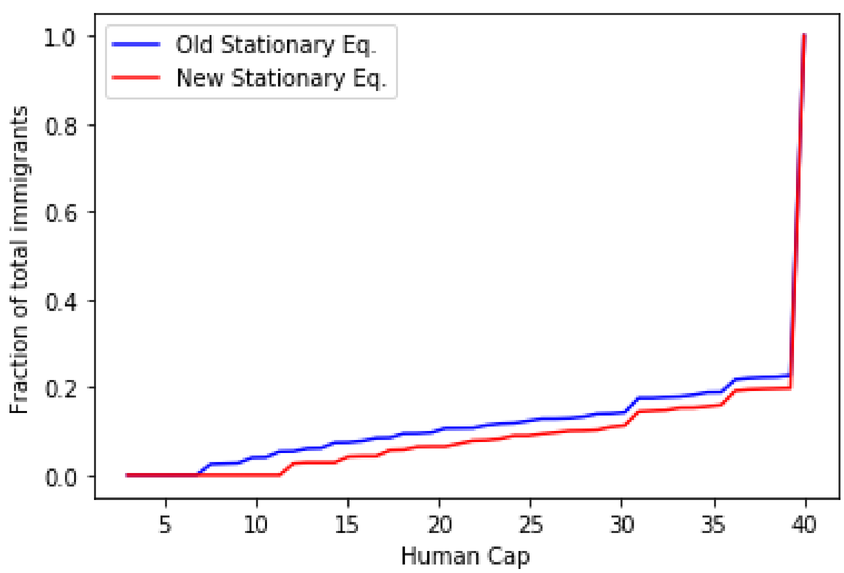

Figure D.7: Human Capital Distribution of Immigrants in R

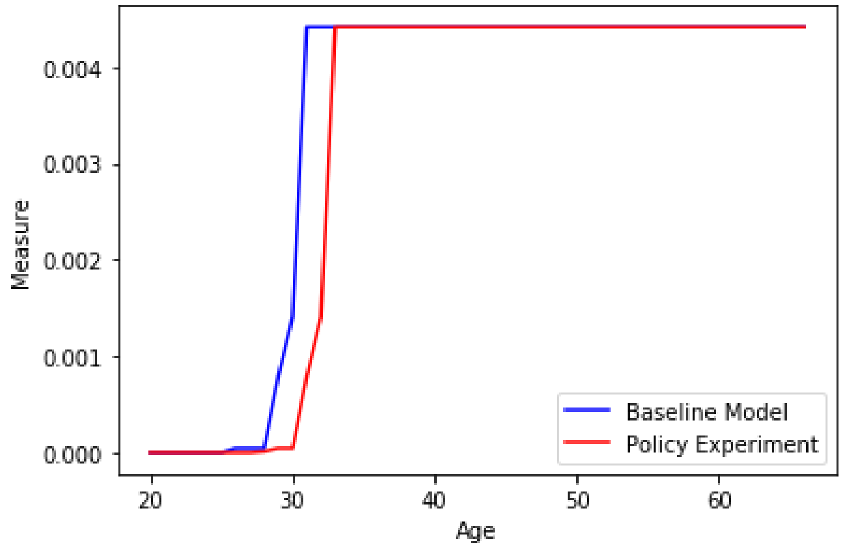

Figure D.8: Human Capital Distribution of Immigrants in R

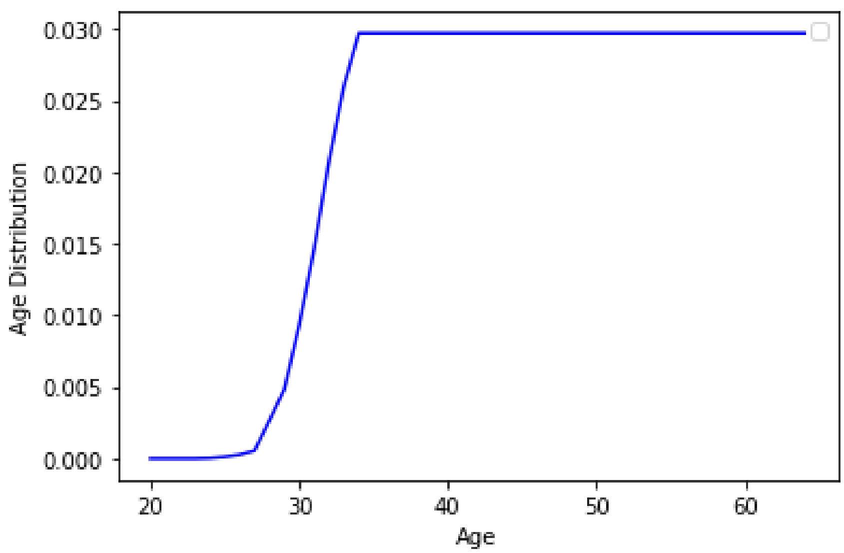

Figure D.9: Age Distribution of Immigrants in R

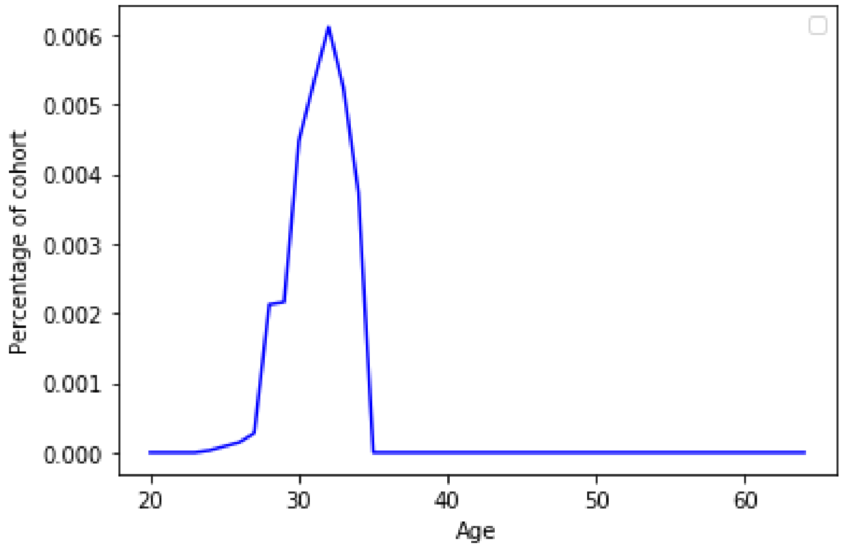

Figure D.10: Age of Relocation to R

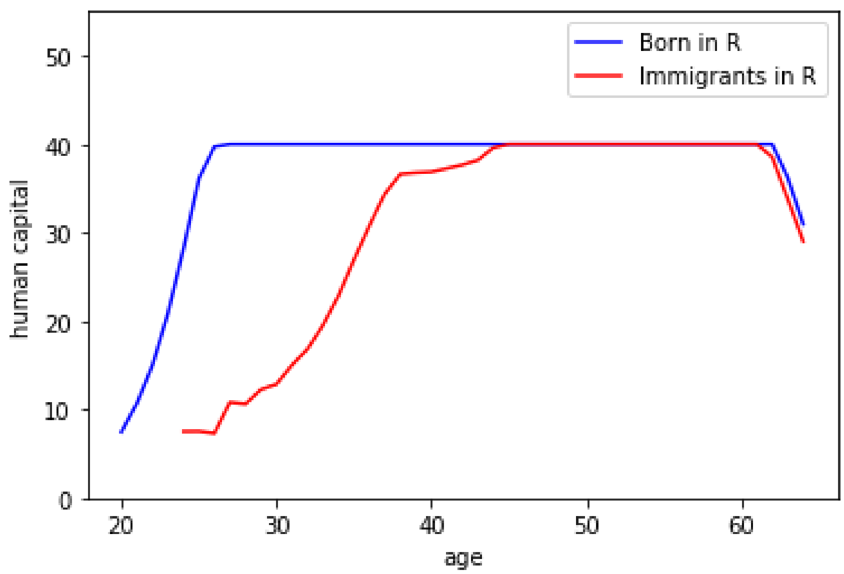

Figure D.11: Human Capital by Age

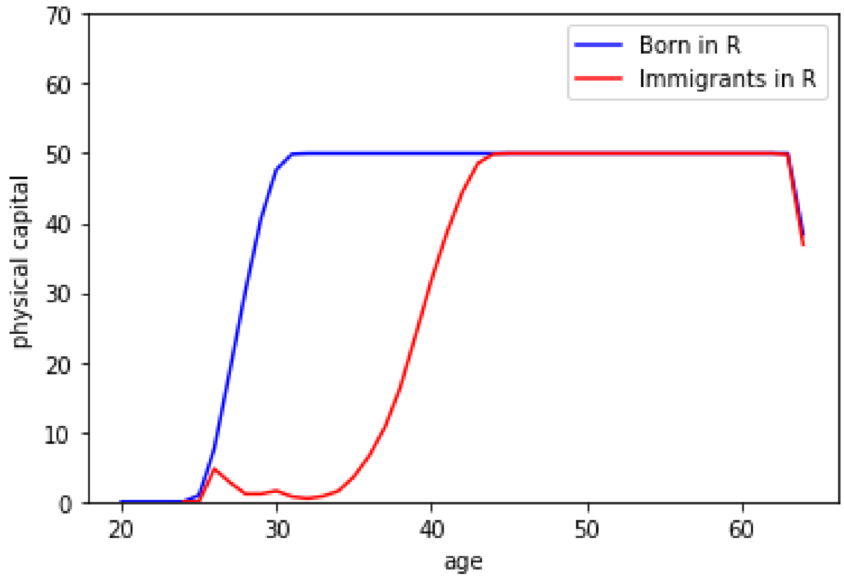

Figure D.12: Physical Capital by Age